TM 11-341

WAR DEPARTMENT TECHNICAL MANUAL

TELEPHONE TERMINAL SETS TC-21-A and TC-21-B (CARRIER) and REPEATER SET TC-23-A (CARRIER)

WAR DEPARTMENT • *OCTOBER 1945*

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ERRATA SHEET

This Technical Manual TM-11-341 under Figures 82, 83, 84, 86, 87, 88, 90, 91, 93 and 95 depicts the use of wire in accordance with the manufacturer's standards, which has been replaced in this bay with hook-up wire in accordance with WL type wire per JAN-C-76. All WL type wire is furnished with a polyvinyl chloride insulation and a nylon jacket.

Wire codes as shown under the above figures and their replacing codes are shown under the following table:

Manufacturer's Code	JAN-C-76 Code
14 AB Wire	WL 4 (19) 14C (plus color)
16 AM Wire	WL 2 1/2 (1) 16C (plus color)
16 Ga. Wire per KS 9819	WL 2 1/2 (19) 16C (plus color)
20 AM Wire	WL 1 (1) 20C (plus color)
20 Ga. Wire per KS 9819	WL 1 (7) 20C (plus color)
22 AM Wire	WL 3/5 (1) 22C (plus color)
22 Ga. Wire per KS 9819	WL 3/5 (7) 22C (plus color)
22 Ga. Wire per D-169970 or 22P	*WL 3/5 (7) 22C (plus color)

See following information for colors.

* This wire is also equipped with a shield per KS 9933 and a 22 AWG bare tinned copper wire included under the shield and run longitudinally as a ground.

Color Conversion Table

Color Under TM-11-341 Figs.	JAN-C-76 Colors Used
BK	BK
BR	BR
R	R
O	O
Y	Y
G	G
BL	BL
S	S
W	W
BK-R	W-BK-R
BR-R	W-BR-R
R-G	W-R-G
O-R	W-R-O
Y-G	W-Y-G
G-W (single)	G
BL-R	W-R-BL
S-R	W-R-S
R-S	W-R-S
G, G-W (pair)	R, W-S-G

It should be noted that the wiring diagram circuit labels affixed to the inside of the case, adequately cover the use and description of the hook-up wire used herein.

Spares

The Line Amplifier, Fig 18 does not provide the spare vacuum tubes depicted therein for the TC-21-B Telephone Terminal. Reference to four spare vacuum tubes on amplifier panel under Sect. 1 Paragraph 14 (a) and under Paragraph 25 reference to 8 instead of 4 spare vacuum tubes is erroneous.

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-341

This manual supersedes TM 11-341, 8 April 1943, including C 1, 12 October 1944

TELEPHONE TERMINAL SETS TC-21-A and TC-21-B (CARRIER) and REPEATER SET TC-23-A (CARRIER)

WAR DEPARTMENT • OCTOBER 1945

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TM 11–341, Telephone Terminal Sets TC–21–A and TC–21–B (Carrier) and Repeater Set TC–23–A (Carrier), is published for the information and guidance of all concerned.

[AG 300.7 (22 May 45)]

BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff

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Refer to FM 21–6 for explanation of distribution formula.

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DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Panels, switchboards, instrument boards, controls, switches, relays, meters, power units, batteries, keys, phones, etc.
2. Cut—All wiring in electrical equipment.
3. Burn—All circuit labels, wiring diagrams, Technical Manuals, condensed instructions, etc.
4. Bury or scatter—All parts destroyed.

DESTROY EVERYTHING

SAFETY NOTICE

When power is connected, dangerous voltages may exist on certain terminals of the repeater, power supply, and signaling circuits. Accordingly, operators are cautioned against touching any live terminal and any other metal at the same time. When changing connections in the amplifier, power supply, or signaling circuits, the a-c power should be disconnected if practicable. If tests are to be made which may involve touching live terminals it will be desirable to stand on a dry board or other insulated platform in order to avoid danger. This does not apply to equalizers, attenuators, or balancing circuits, but it will be desirable to exercise caution in touching composite sets and protector circuits since these may be connected to telegraph potentials, or the live wires may possibly be charged through accidental contact with power wires or by atmospheric discharges.

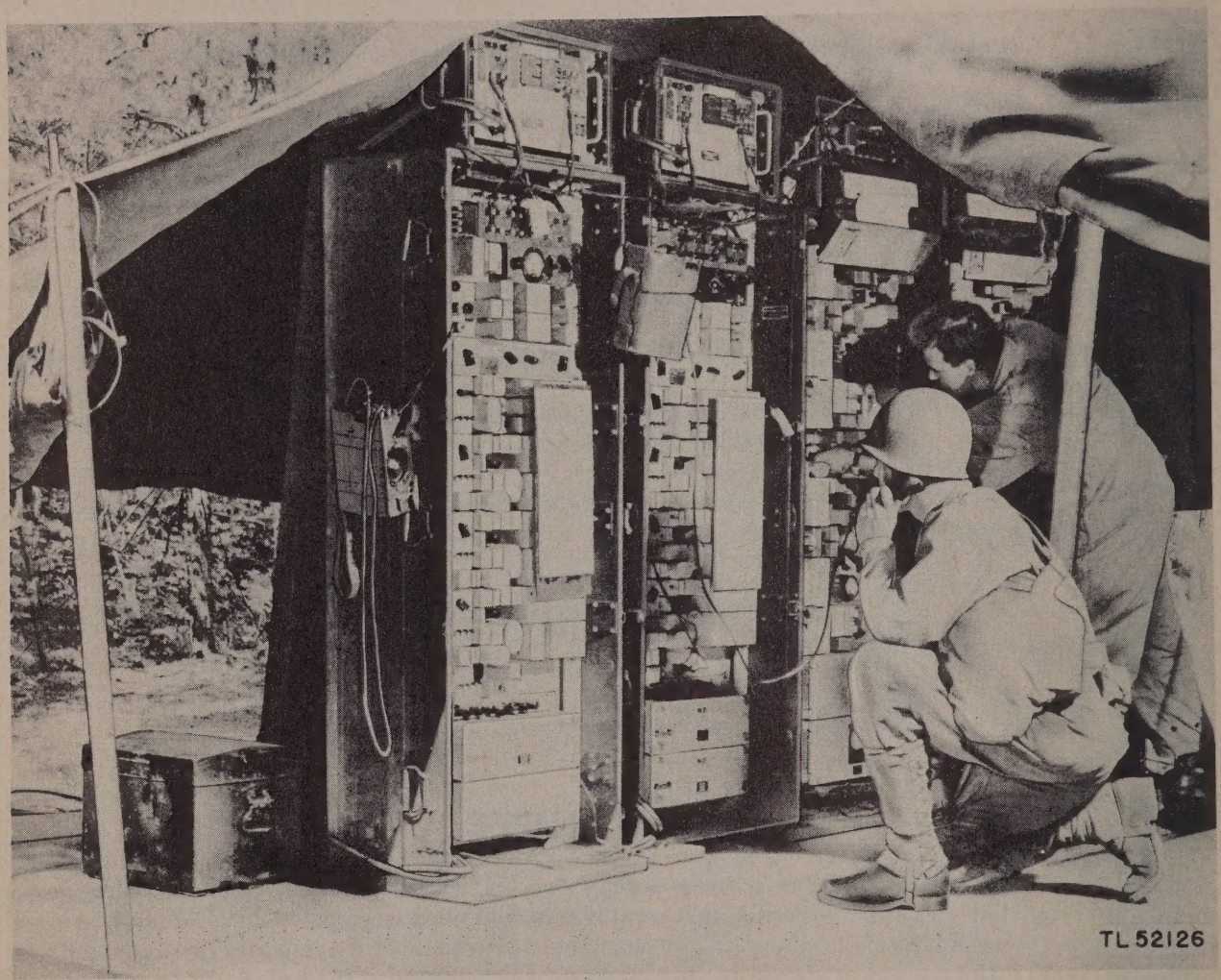

Figure 1. Typical installation of Telephone Terminal Set TC–21–A.

PART ONE

INTRODUCTION

Section I. DESCRIPTION OF TELEPHONE TERMINAL SET TC-21-(*) AND REPEATER SET TC-23-A

1. General

a. This Technical Manual describes Telephone Terminal Set TC-21-A (Carrier), Telephone Terminal Set TC-21-B (Carrier), and Repeater Set TC-23-A (Carrier). These sets are used in a carrier telephone system to provide four telephone channels of which one is a voice-frequency channel and three are carrier channels. The four channels operate within a frequency band of 200 to 12,000 cycles per second, each channel requiring a band of approximately 2,600 cycles per second in width. Figure 2 is a general schematic diagram of a carrier system.

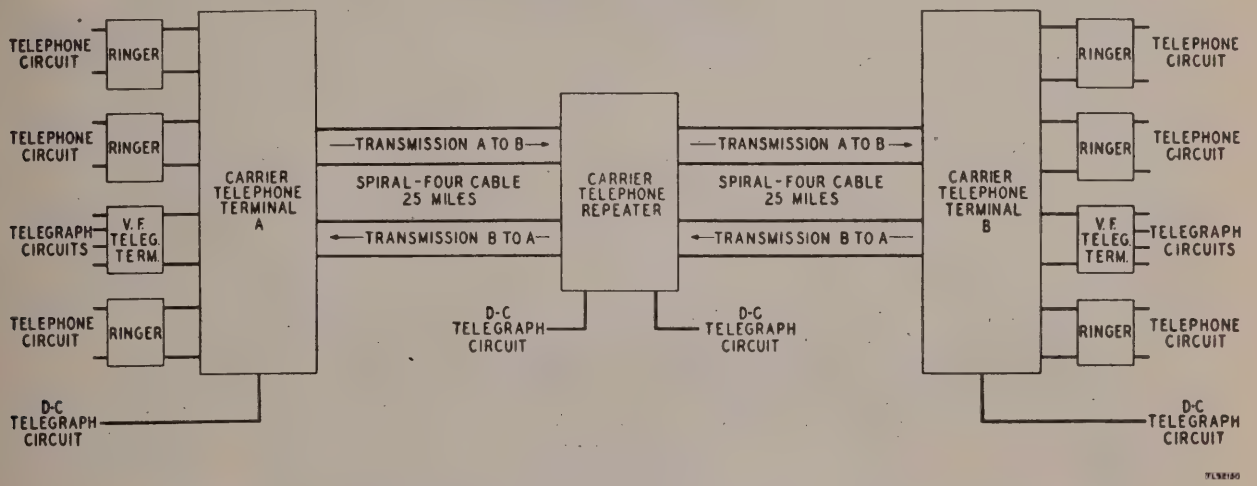

Figure 2. General schematic diagram of a carrier system.

b. Telephone Terminal CF-1-A (Carrier) is the principal component of Telephone Terminal Set TC-21-A (Carrier). Telephone Terminal CF-1-B (Carrier) is the principal component of Telephone Terminal Set TC-21-B (Carrier). Repeater CF-3-A (Carrier) is the principal component of Repeater Set TC-23-A (Carrier).

Note.—Throughout this manual, Telephone Terminal Set TC-21-(*) (Carrier) refers to Telephone Terminal Set TC-21-A or TC-21-B, Telephone Terminal CF-1-(*) (Carrier) refers to Telephone Terminal CF-1-A or CF-1, B. Telephone EE-8-(*) refers to Telephone EE-8 EE-8-A, or EE-8-B.

c. Telephone Terminal CF-1-A (Carrier) provides for two-wire channel termination, and Telephone Terminal CF-1-B (Carrier) provides for either two-wire or four-wire channel termination. Telephone Terminal CF-1-A may be arranged to provide for a four-wire termination. (See par. 48.) A two-wire termination is normally used with the channels connected to a telephone switchboard, Telephone EE-8-(*), a voice-frequency telegraph system operated on a two-wire basis, or when a circuit is bridged onto the carrier channel at a terminal. A four-wire termination is normally used when channels of two systems using Telephone Terminals CF-1-B are connected in tandem, when a voice-frequency telegraph system is operated on a four-wire basis over a carrier telephone channel, when a channel of a system using Telephone Terminal CF-1-B at a junction point is connected to a channel of Carrier Terminal OA-11/FC, OA-12/FC, Carrier Terminal OA-13/FC, or when a channel is extended over a radio link.

d. Telephone Terminals CF-1-A and CF-1-B and Repeater CF-3-A are designed for operation

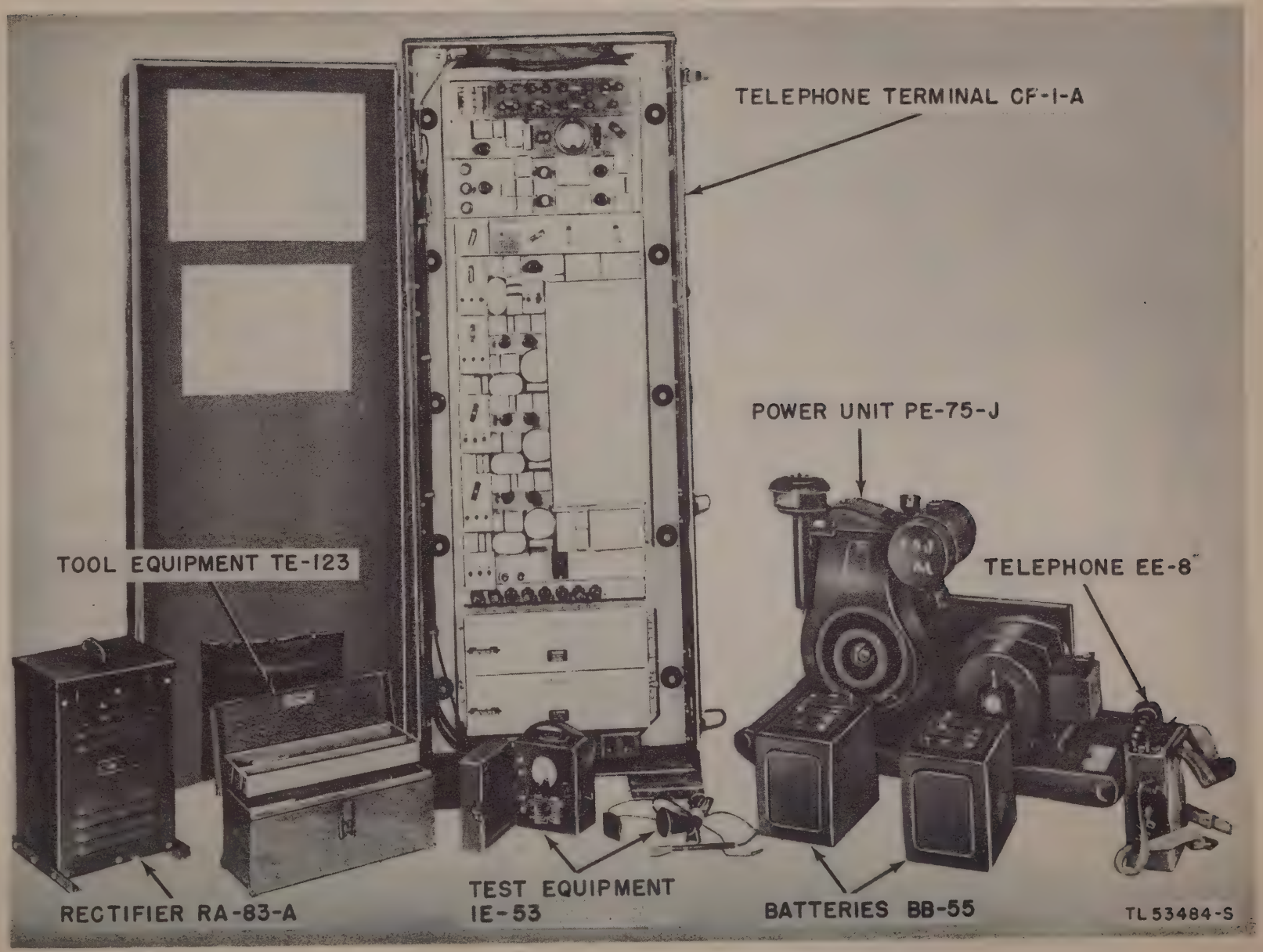

Figure 3. Telephone Terminal Set TC-21-A (Carrier), principal components.

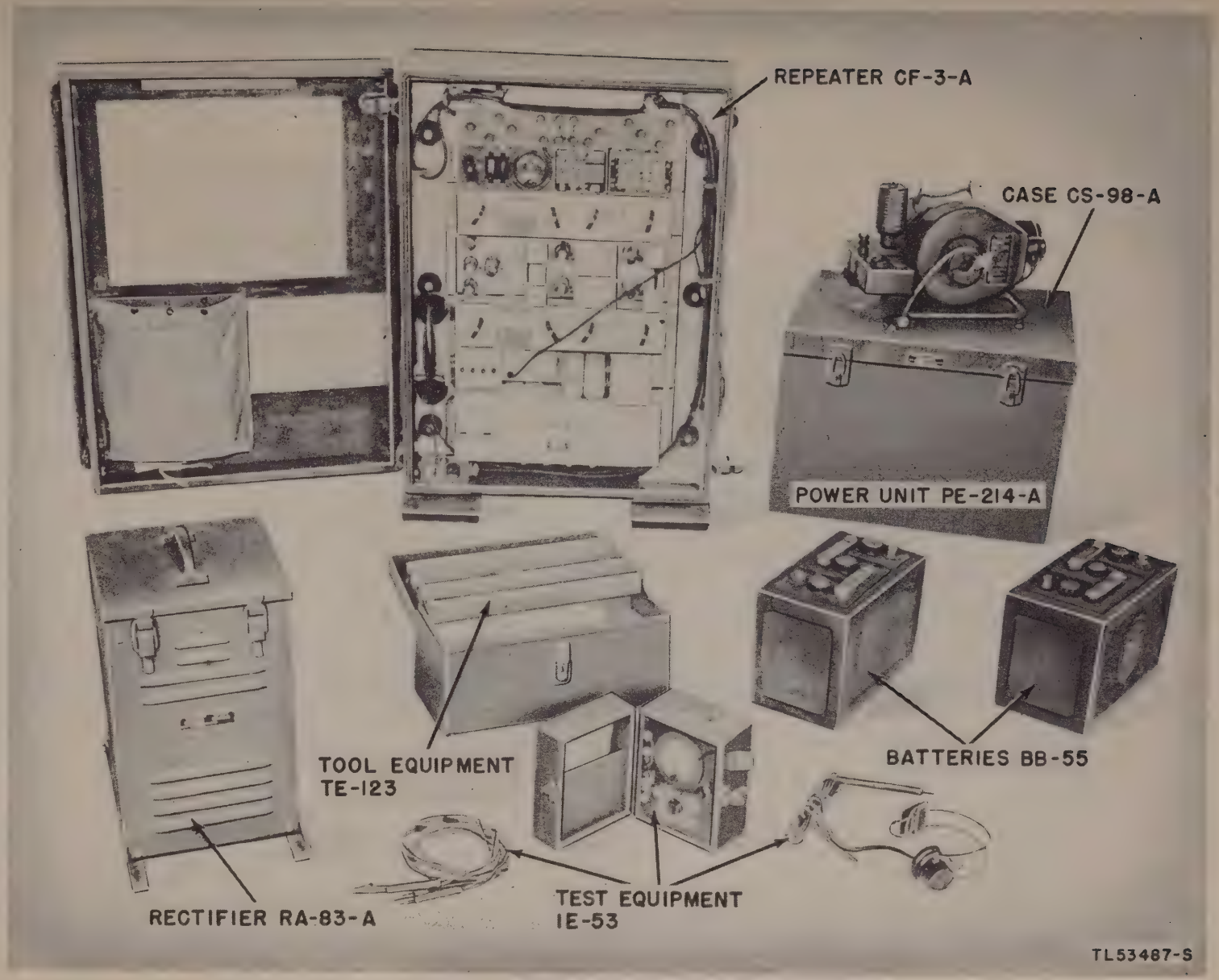

Figure 4. Repeater Set TC-23-A (Carrier), principal components.

over spiral-four cable lines consisting of cable assemblies; however, operation may be over open-wire lines. (See par. 42.)

e. When operation is over spiral-four cable without repeaters, circuit lengths up to 45 miles may be used. With Repeaters CF–3–A spaced about 25 miles apart, circuit lengths up to 150 miles may be used with the cable on the ground or overhead, and up to 400 miles with the cable buried. Operation over open wire may be with four wires or two wires. For two-wire operation, Carrier Hybrid CF–7 is used as accessory equipment. (See par. 43.)

f. Converter CF–4 (Carrier, 2-wire—4-wire) and Repeater CF–5 (Carrier, 2-wire) are used to provide four circuits over a single open-wire pair.

g. Operation is also possible making use of radio to form links in the wire circuits with the carrier frequency passing over the wire and radio links in combination. (See par. 47 and TM 11–2601.)

h. In emergencies, when Cable Assemblies CC–358 or open wire are not available, nonloaded Wire W–143 can be used in a carrier system with Telephone Terminal Sets TC–21–(*) (Carrier) and Repeater Set TC–23–A (Carrier). Further description of the use of this wire is given in paragraph 40.

i. Voice-frequency signaling is used by ringing over the circuits provided by this system. Ringing Equipment EE–101–A is required at each terminal for circuits used for telephone purposes.

j. Talking and monitoring facilities are provided for talking over each of the channels between terminals and over channel 1 between a terminal and a repeater. In addition, Telephone EE–8–(*) or Telephone Unit EE–105 may be used in talking over channel 1.

k. Transmission measuring equipment required for system line-up and maintenance is included in terminals and repeaters.

l. A telegraph system made up of Telegraph Terminal CF–2–A (Carrier) (TM 11–355), Telegraph Terminal CF–2–B (Carrier) (TM 11–355B), or Telegraph Terminal CF–6 (Carrier) (TM 11–2009) providing voice-frequency telegraph circuits may be operated over this carrier telephone system.

m. The power requirements are a source of 115-volt or 230-volt, 50- to 60-cycle alternating current (ac) or a 12-volt storage battery. Two 6-volt storage batteries connected in series may be used as 12-volt storage battery for emergency operation in case of failure of the regular a-c supply.

2. List of Major Components

a. The items listed below are the major components of Telephone Terminal Set TC–21–(*) (Carrier). See section XVII for a complete list of component parts.

Quantity	Component	Weight (pound)	Dimensions	Volume (cubic feet)
1	Telephone Terminal CF–1–A (Carrier) or Telephone Terminal CF–1–B (Carrier). (Package No. 1).	475	5′ 6″ x 2′ 4″ x 1′ 7″	20. 319
2	Power Unit PE–75–(*). (Package No. 5.)†	330 (each)	3′ x 1′ 7″ x 2′ 2½″ (each)	10. 489 (each)
2	Batteries BB–55. (Package No. 2.)	55 (each)	2′ 2″ x 1′ 2″ x 1′ 7″	4. 002
1	Rectifier RA–83–A. (Package No. 7)	57	1′ 2″ x 10″ x 1′ 4″	1. 296
1	Test Equipment IE–53. (Package No. 3)	8	7″ x 6″ x 5½″	. 133
1	Tool Equipment TE–123. (Package No. 3)	20	7″ x 1′ 4″ x 7″	. 453
1	Telephone EE–8–(*). (Package No. 3)	10	4″ x 8″ x 10″	. 185
	Accessory equipment and spare parts. (Packages Nos. 4, 6, and 8.)			

†Each Power Unit PE–75–(*) is shipped in a box labeled Package 5.

b. The items listed below are the major components of Repeater Set TC–23–A:

Quantity	Component	Weight (pound)	Dimensions	Volume (cubic feet)
1	Repeater CF–3–A. (Package No. 1)	225	2′ 4″ x 1′ 2″ x 2′ 10″	7. 7129
1	Power Unit PE–214–(*). (Package No. 5)	40	1′ 2″ x 1′ 6½″ x 10″	1. 4988
2	Batteries BB–55. (Package No. 2)	55 (each)	2′ 2″ x 1′ 2″ x 187″	4. 002
1	Rectifier RA–83–A. (Package No. 7)	57	1′ 2″ x 10″ x 1′ 4″	1. 296
1	Test Equipment IE–53. (Package No. 3)	8	7″ x 6″ x 5½″	. 133
1	Tool Equipment TE–123. (Package No. 3)	20	7″ x 1′ 4″ x 7″	. 453
	Accessory equipment and spare parts. (Packages Nos. 4 and 6.)			

3. Telephone Terminal CF–1–(*) (Carrier)

a. The panels of the carrier terminal equipment are mounted on two vertical steel strips secured by steel bars at the top and bottom of the terminal bay. This frame is supported as a unit by shock-absorbing disks mounted inside two steel U-channels. These channels extend vertically the height of the bay. The U-channels are bolted to the sides of the wooden case. The front of the channels and the front of the rubber disks are

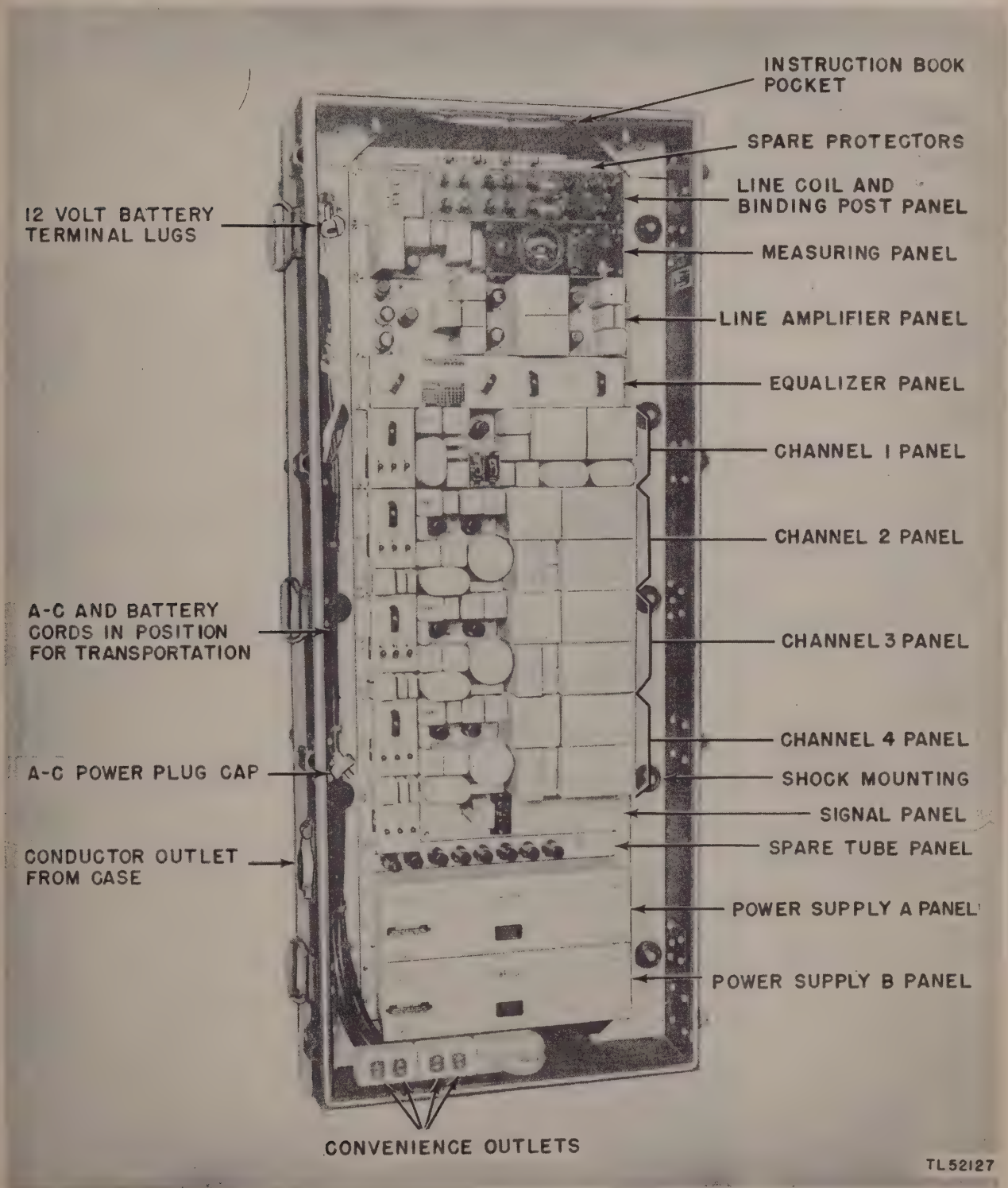

Figure 5. Telephone Terminal CF–1–A (Carrier), front view, cover removed.

shown in figures 5 and 6. The carrying case is made of plywood and is painted olive drab. The case has removable front and back covers which are held in place by trunk drawbolts. Three carrying handles are provided on each side of the case. Skids are provided on the sides and on the rear cover to protect the handles and to facilitate sliding of the case. The terminal and the case weigh about 475 pounds.

b. Units requiring adjustments, such as dials,

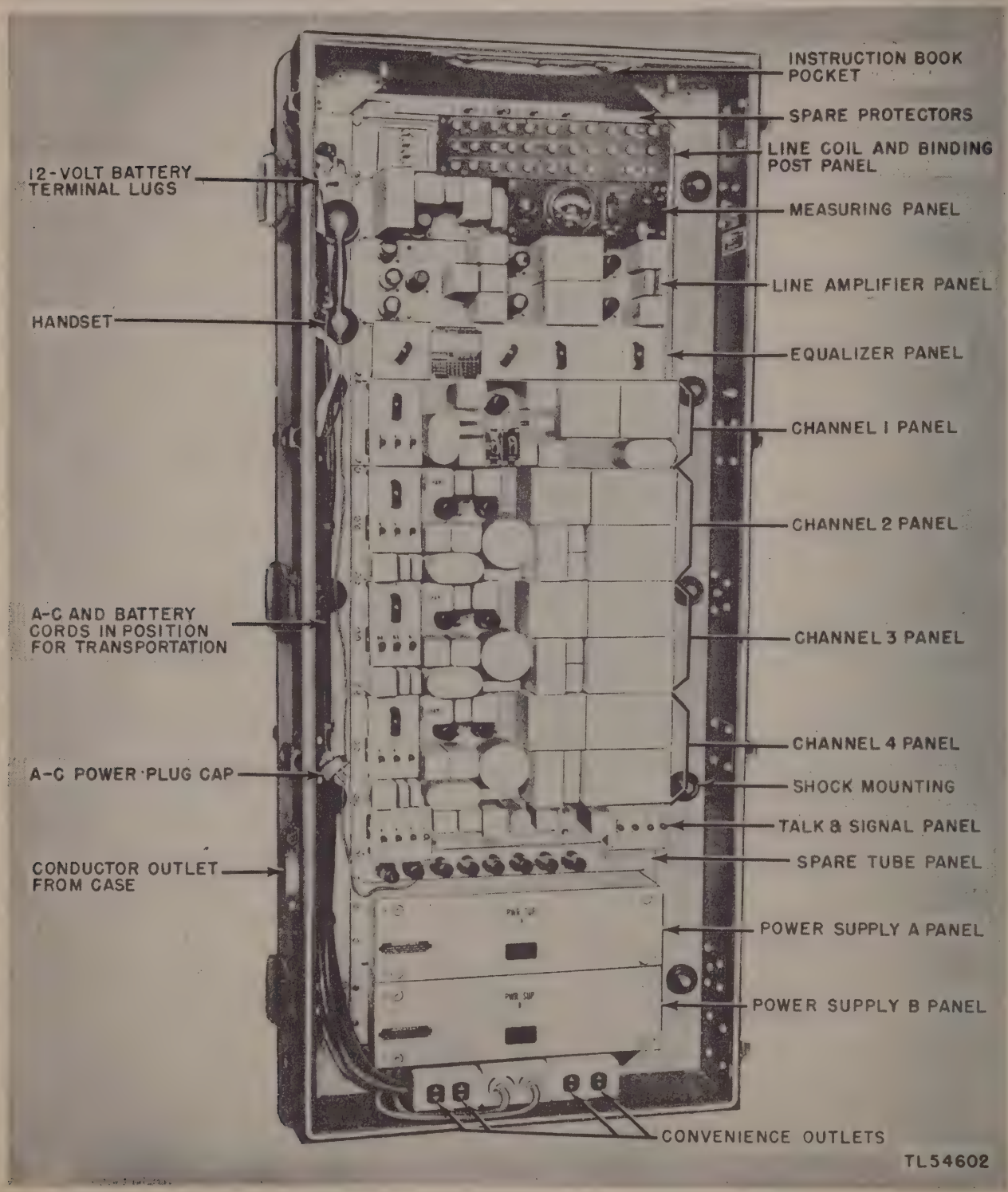

Figure 6. Telephone Terminal CF–1–B (Carrier), front view, cover removed.

keys, etc., are mounted on the front of the panels. The wiring is run on the rear of the panels. The power cords for connecting the a-c power supply and for connecting the 12-volt battery extend from the bottom of the bay. Rings and fabric tie-cords are provided around the bay framework for carrying and securing the cords in transit.

c. The binding post panel is located at the top of the rack. The binding posts are insulated to minimize chance of shock while connections are being made.

d. An opening is provided in the side of the case to permit bringing out external connections, such as the power leads, cable stubs, and leads to the channel terminals. This opening is fitted with a cover held closed by a spring so that the front and rear covers may be left on during operation when necessary to protect the equipment from the weather.

e. A system diagram and schematic circuit diagram are mounted inside the front cover. Wiring diagram circuit labels are mounted inside the rear cover. A summary of operating instructions, which is condensed from the instructions given in this manual, is mounted inside the front cover of the bay. A copy of the Technical Manual is placed in the holder located on the inside of the front cover, and a second copy is placed in the holder at the top of the case.

4. Repeater CF–3–A (Carrier)

a. The carrying case and the construction of the frame of Repeater CF–3–A resembles the case and frame of the telephone terminal equipment. As on the terminal equipment, the covers are equipped with skids to facilitate sliding the unit. The front and rear covers are removable. When the covers are in place they are held fast by trunk drawbolts. The power cords and battery cords are brought up from the bottom of the bay along the right-hand side of the frame of the bay and under the top of the frame, being held by fabric tie-cords and cable rings. The ends of these cords are fastened at the upper left-hand corner of the bay. A handset is suspended from the lower left-hand side of the frame.

b. As on the terminal equipment, dials and keys are mounted on the front of the panels and the wiring is run on the rear of the panels.

c. The binding post panel is located at the top of the bay. The binding posts are insulated to lessen chance of shock while connections are being made.

d. An opening is provided in the right-hand side of the case to allow bringing out the conductors.

e. A system diagram and schematic circuit diagram are mounted inside the front cover. Wiring diagram circuit labels are mounted inside the rear cover. A summary of operating instructions, a condensation of instructions given in this manual, is mounted on the front of the bay. A copy of the Technical Manual is placed in the holder inside the front cover, and a second copy is placed in the holder at the top of the bay.

5. Power Unit PE–75–(*)

Power Unit PE–75–(*), a component of Telephone Terminal Set TC–21–(*), consists essentially of a gasoline engine and a self-excited generator. The engine is a single-cylinder, air-cooled gasoline engine designed to develop 6.5 horsepower (hp) at 2,400 revolutions per minute (rpm). The generator is rated at 2,500 watts, 100 percent power factor, single phase, 60 cycles, and 120 volts at 1,800 rpm and 50° C. temperature rise. The unit weighs about 330 pounds and is approximately 36 by 19 by 27 inches over-all. A complete set of tools is provided with the unit. For further information on Power Unit PE–75–(*), see TM 11–900.

Note.—Power Unit PE–75–(*) refers to Power Units PE–75–C through –W and PE–75–AA through –AE.

6. Telephone EE–8–(*)

Telephone EE–8–(*) is designed for field use on either local battery or common battery systems. The unit contains all the elements necessary for a combination local battery and common battery telephone, and circuit elements are arranged for antisidetone transmission. For further information regarding Telephone EE–8–(*), see TM 11–333.

7. Rectifier RA–83–A

Rectifier RA–83–A is a tube type rectifier which converts 115- or 230-volt, 50- to 60-cycle, a-c power to direct current for charging 6- or 12-volt storage batteries. The maximum power input is approximately 325 watts with a full load on the d-c output. The output available is 20 amperes at 6.0 volts or 10 amperes at 12.0 volts. For further information regarding Recifier RA–83–A, see TM 11–963.

8. Power Unit PE–214–(*) (TM 11–945)

Power Unit PE–214–(*), a component of Repeater Set TC–23–A, is a lightweight electric generating set consisting of gasoline Engine GE–12–(*) and a-c Generator GN–51–(*). It is designed to deliver 300 watts at 120 or 240 volts alternating

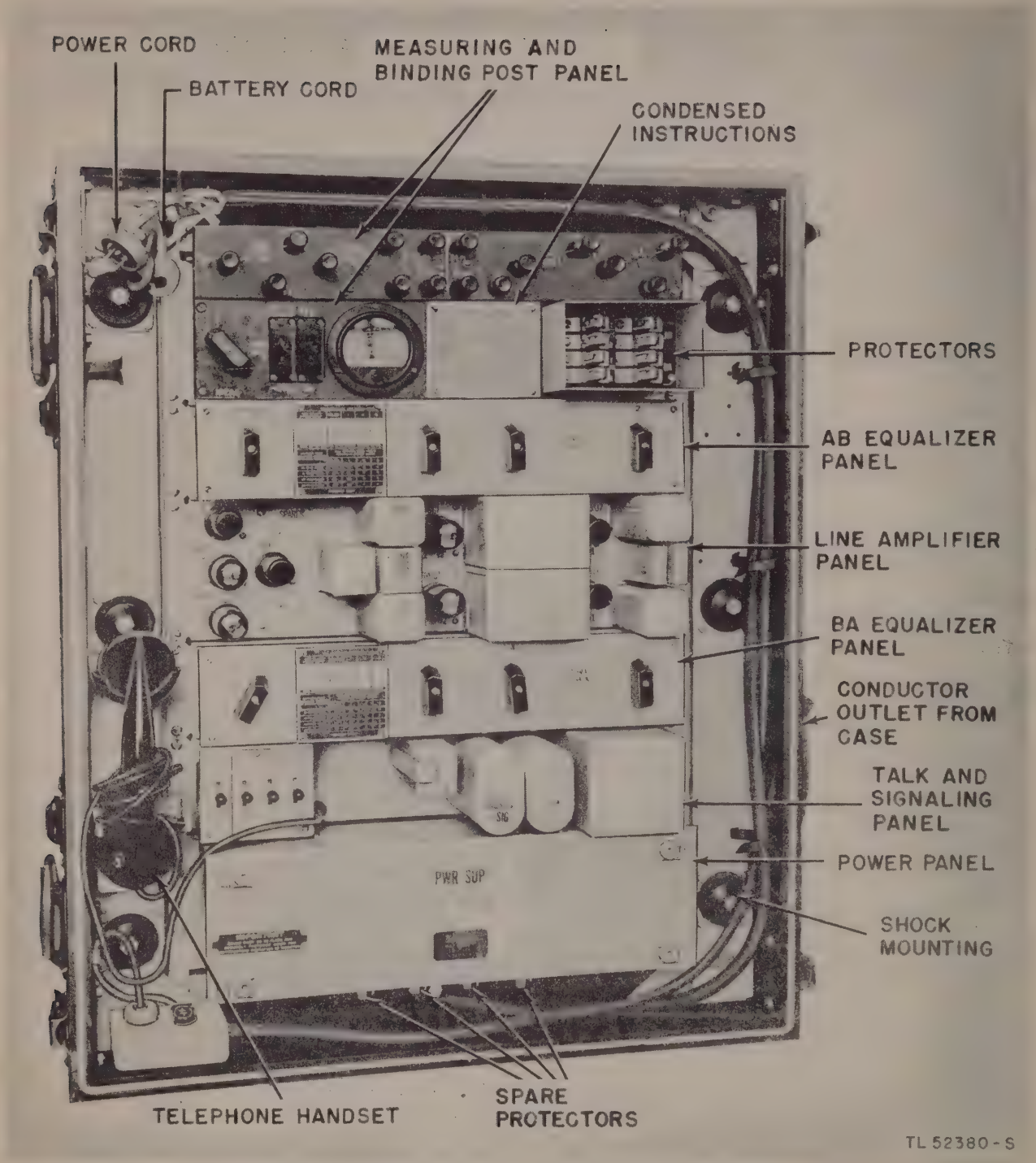

Figure 7. Repeater CF–3–A (Carrier), front view, cover removed.

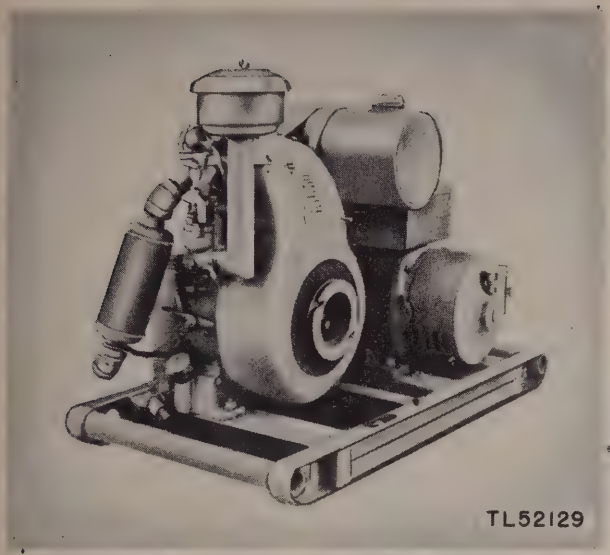

Figure 8. Power Unit PE–75–W.

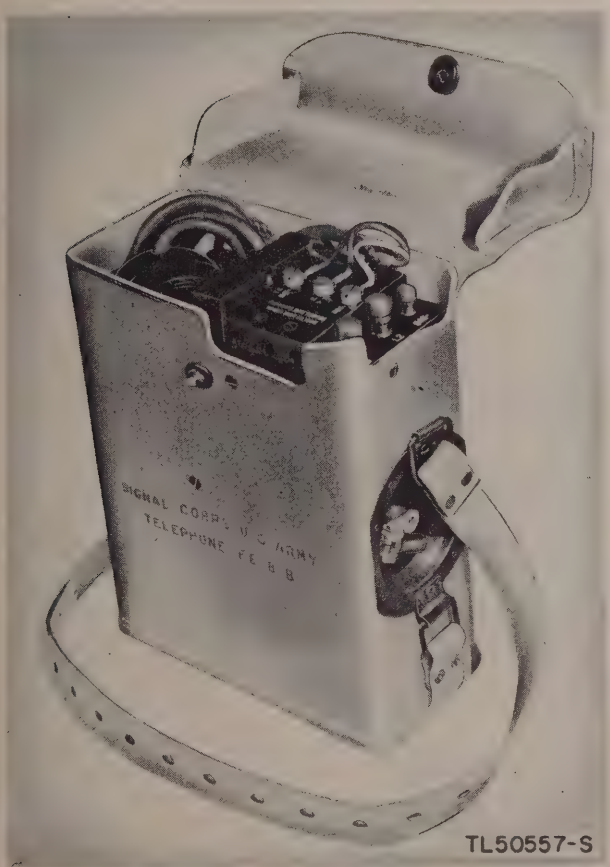

Figure 9. Telephone EE–8–B.

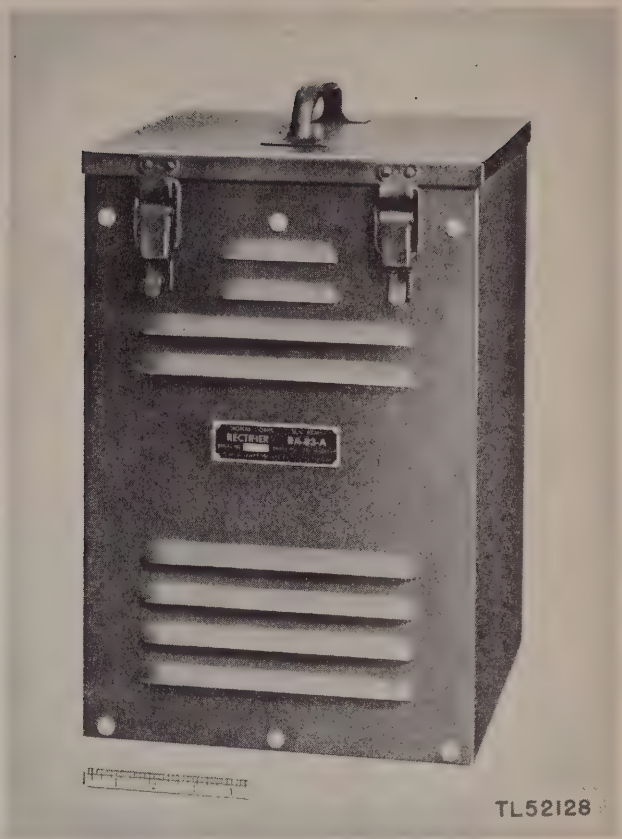

Figure 10. Rectifier RA–83–A.

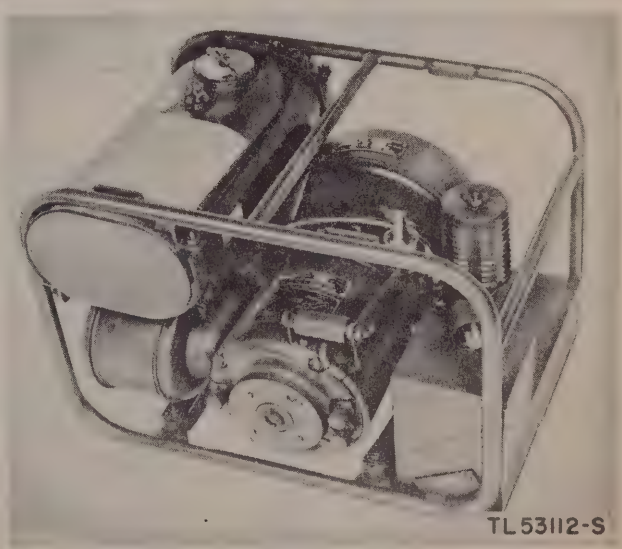

Figure 11. Power Unit PE–214–B.

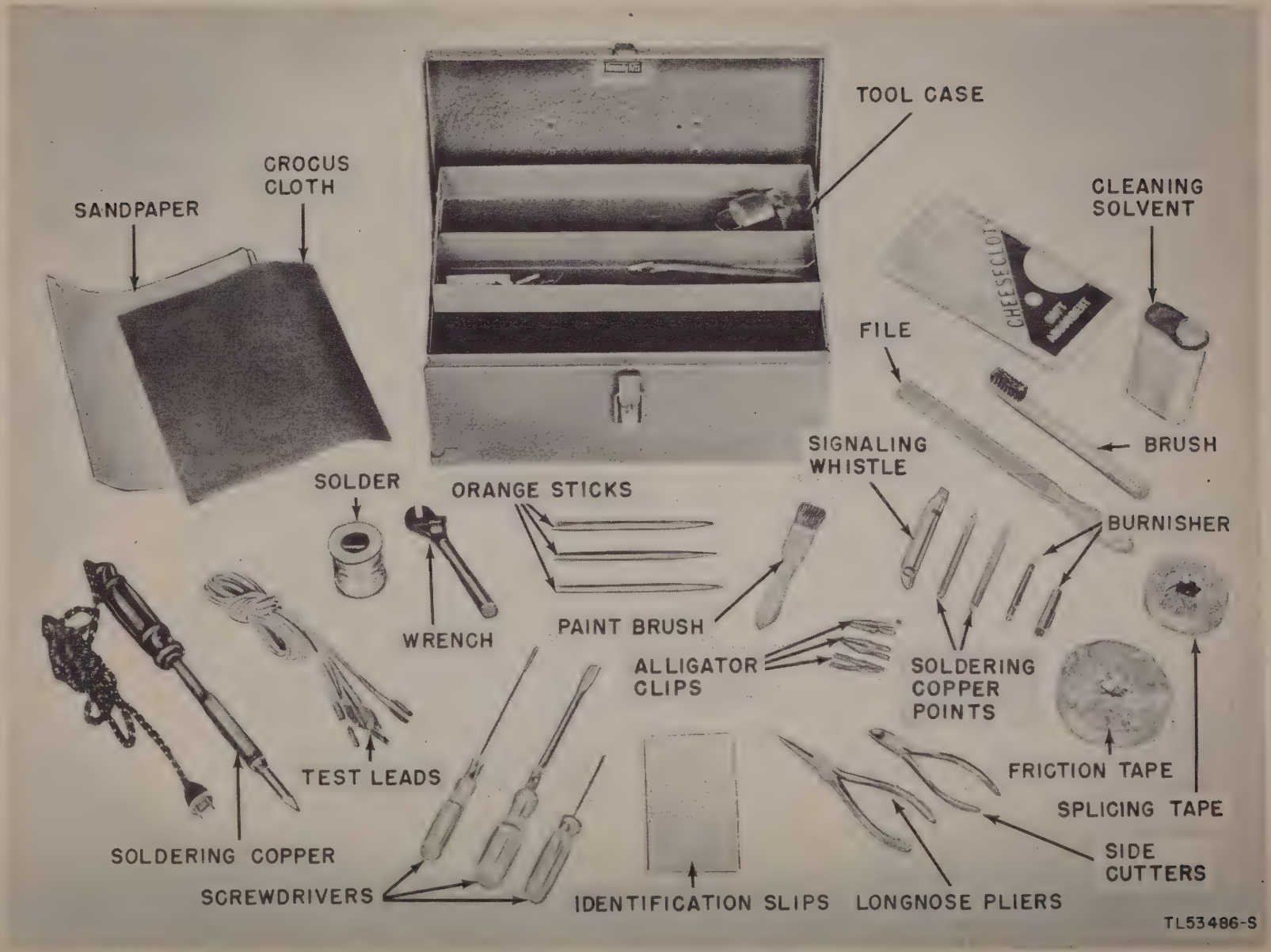

Figure 12. Tool Equipment TE–123.

current. Engine GE–12–(*) is a single-cylinder, air-cooled, two-cycle gasoline engine which develops 1 horsepower (hp) at 3,000 rpm. Generator GN–51–(*) is a single-phase, 60-cycle, revolving-field type unit which is coupled directly to the engine crankshaft. For further information on Power Unit PE–214–(*), see TM 11–945.

Note.—Power Unit PE–214–(*) refers to Power Unit PE–214–A or PE–214–B. Generator GN–51–(*) refers to Generator GN–51–A or GN–51–B. Engine GE–12–(*) refers to Engine GE–12–A or GE–12–B.

9. Tool Equipment TE–123

Tool Equipment TE–123 consists of tools and materials for use in maintenance work on Telephone Terminals CF–1–A and CF–1–B and Repeater CF–3–A, including minor repairs and replacements, and in the cleaning and readjustment of the mechanical parts of contacts, keys, relays, switches, etc., of these equipments.

10. Test Equipment IE–53

Test Equipment IE–53 consists of Voltohmmeter I–166 and Test Set TS–190/U.

a. Voltohmmeter I–166. This is a general-purpose measuring instrument used for checking the continuity, insulation, and resistance of the line conductors; and for checking continuity of the equipment, measuring resistances, etc. The voltmeter part may be used for measuring either a-c or d-c voltages. TM 11–2613 gives a detailed description of Voltohmmeter I–166.

b. Test Set TS–190/U. Test Set TS–190/U consists of a very efficient, 1,000-ohm telephone receiver with a switch-controlled external resistance of 50,000 ohms.

(1) The test set is equipped with a three-conductor test cord, two conductors of which are connected to a test pick and a switch in the test-pick handle for controlling the external resistance. The other conductor of the test cord is terminated in a spring socket chuck to which suitable test clips may be attached. The external resistance of 50,000 ohms is normally in series with the receiver element, but may be short-circuited by depressing the switch in the handle of the test pick. The external resistance is provided to protect the ears of the user against excessive clicks when testing for potentials in circuits, and to provide a high-impedance monitoring receiver so that the test set may be bridged across high-impedance circuits without appreciably affecting the circuit performance. The high-impedance receiver may also be bridged across circuit points without shunting down the current enough to cause the relays to release.

(2) Test Set TS–190–U is designed for maintenance and trouble shooting on telephone and telegraph equipment. Faults such as opens, grounds, shorts, and crosses may be located with this test set. When a circuit is completed through the test set between negative battery and ground (positive battery), a click will be heard in the receiver. If Test Set TS–190/U is not available, any conventional watch-case type receiver may be equipped with two test leads and used as a test receiver.

11. Telephone Unit EE–105

Telephone Unit EE–105 is used with, but is not a part of, Telephone Terminal Set TC–21–(*) (Carrier) and Repeater Set TC–23–A (Carrier). It is a portable telephone embodying the operating portions of a Telephone EE–8–(*) and incorporating features to permit it to be used for talking over the voice-frequency channel of a carrier system. It can be used for talking over voice circuits or over the voice-frequency channel of carrier systems at locations between terminals or repeaters without interference to carrier channels. It may also be used to communicate with a similar telephone unit in the same line section or with a carrier terminal or repeater. In addition, the telephone unit can be used to provide a permanent bridged station on either a voice circuit or the voice-frequency channel of a carrier system. For a more detailed explanation of Telephone Unit EE–105 and its application, see TM 11–2014.

12. Battery BB–55

Battery BB–55 is a three-cell, 6-volt, lead-acid type storage battery in a hard rubber container. The battery must be recharged or replaced when the voltage falls below 5.25 volts. Cells are connected in series by connecting straps. The positive electrode is chocolate-colored lead peroxide. The negative electrode is made of gray metallic lead, commonly called spongy lead. Battery BB–55 is approximately 13⅛ inches long by 7⅛ inches wide by 9⅜ inches high. It holds approximately 5,000 cubic centimeters (cc) of electrolyte and weighs 64 pounds when filled.

13. Accessory Equipment

a. Hydrometer HY–2. Hydrometer HY–2 is used for making rapid measurements of the specific gravity of the electrolyte in a storage battery. It consists of a glass syringe containing

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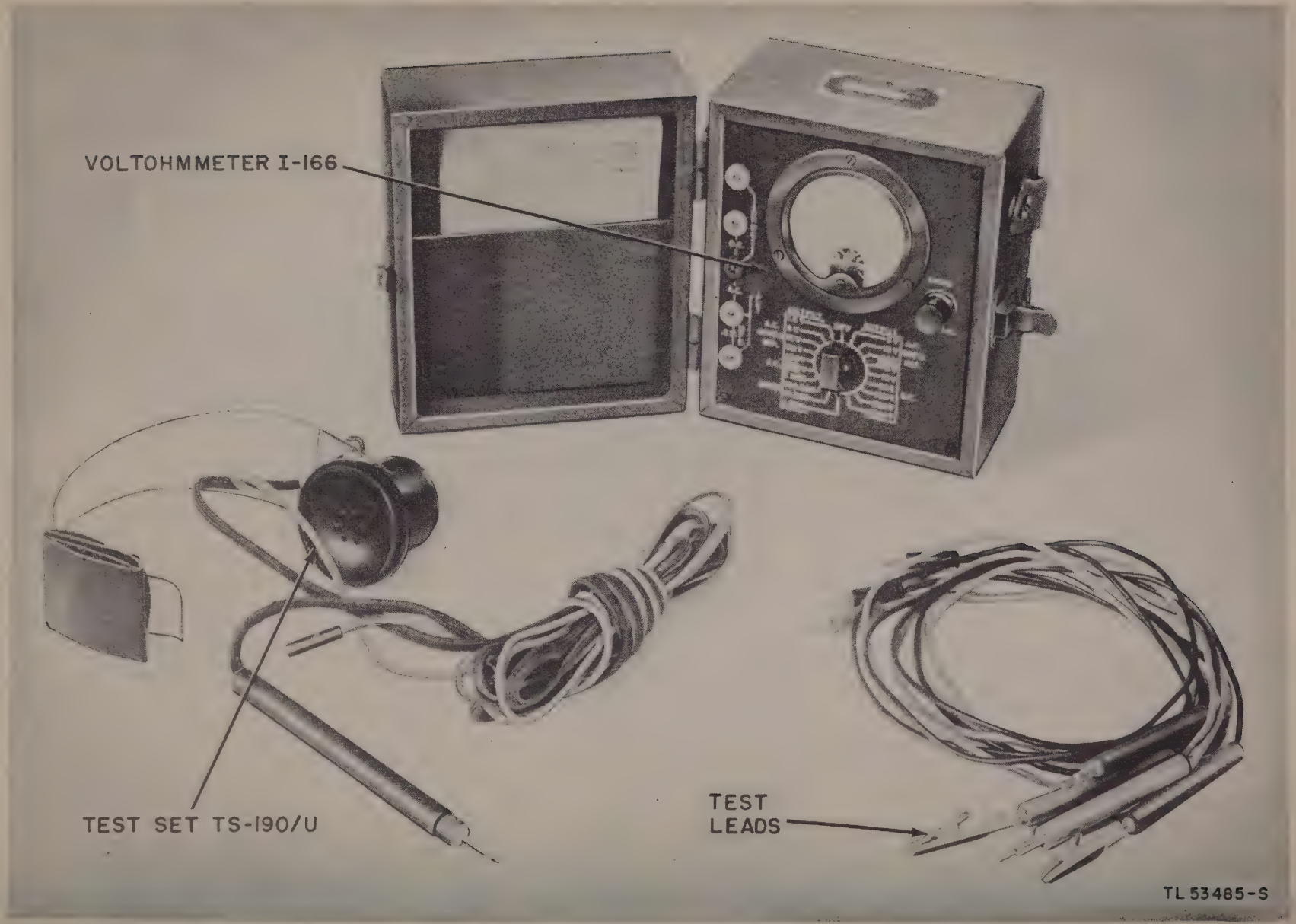


Figure 13. Test Equipment IE-53.

a glass hydrometer float. The glass cylinder of the syringe is topped by a perforated rubber stop and a rubber bulb. The float is a long-necked bottle weighted in the lower end and having a long, thin neck graduated from 1.100 to 1.300.

b. Cable Stub CC–356. Cable Stub CC–356 is used to connect the binding posts of the terminal and repeater equipment to the cable. It consists of a 12-foot length of Cable WC–548, equipped at one end with a connector including a loading coil.

e. Cord CO–711. Cord CO–711 is a two-conductor, 14-gauge wire 50 feet long with a plug cap at one end and a connector at the other. It is used for making connection between Power Unit PE–75–(*) or PE–214–(*) and Junction Box JB–110.

f. Cord CO–38. Cord CO–38 is used for making connection between storage batteries. It is a rubber-covered, single-conductor, 12-gauge, braided and stranded wire 12 feet long with a

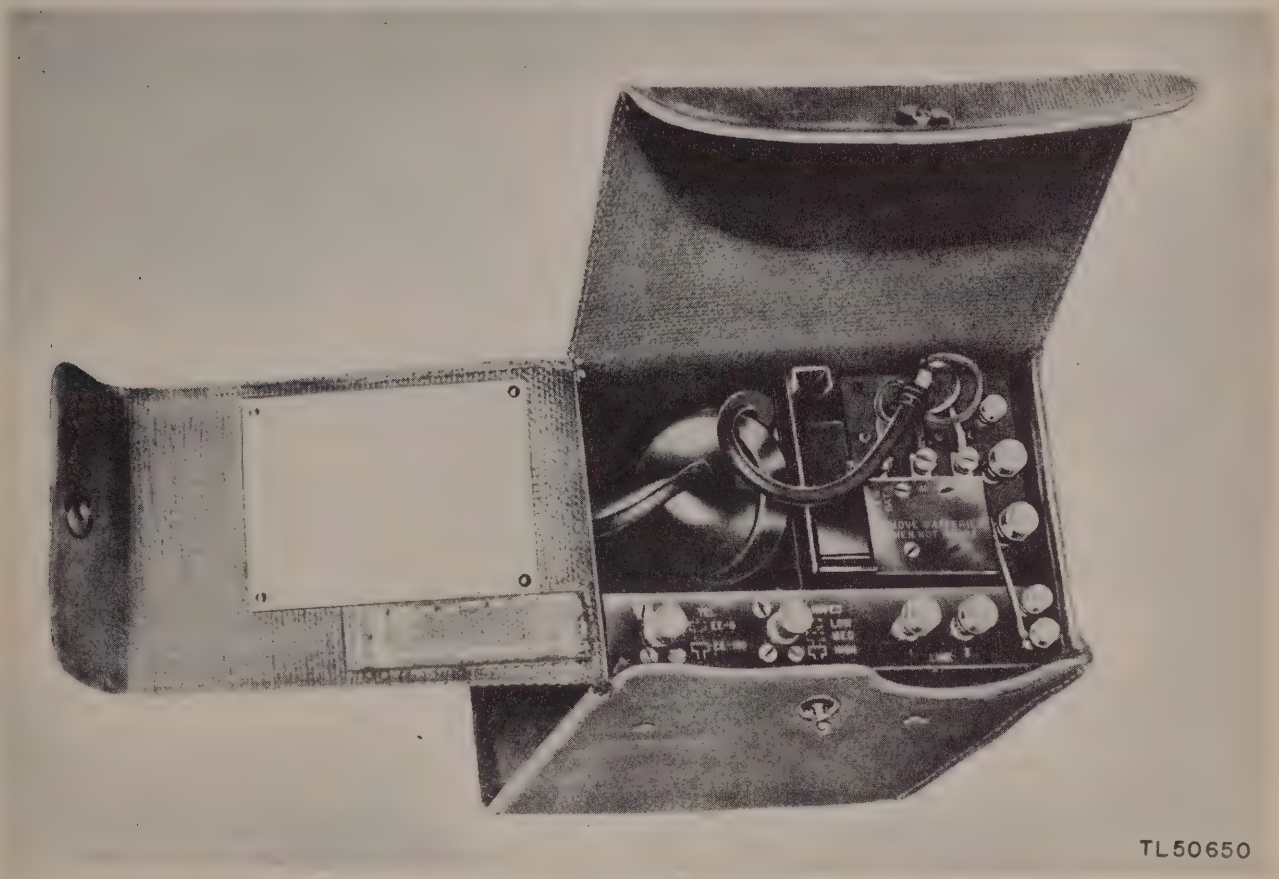


Figure 14. Telephone Unit EE–105.

The other end has the conductors and braid brought out for connection to the binding posts of the equipment. Cable Stub CC–356 weighs about 4.5 pounds.

c. Wire W–2. Wire W–2 is a bare, noninsulated, 14-gauge copper conductor used for connection between the terminal or repeater equipment and ground.

d. Wire W–69–A. Wire W–69–A is a rubber-covered, braided, insulated wire used for interconnecting the units of equipment used with telephone terminal sets when the equipment is located in the same building or in a building adjacent to the terminal.

3-inch rubber tube and Clamp TM 12–A on each end.

g. Battery Terminals. The battery terminals are lead-alloy coated and have brass wingnuts. The battery terminals marked + connect the battery lead to the positive (+) terminal of Battery BB–55. The battery terminals marked — connect the battery lead to the negative (—) terminal of the battery.

h. Ground Rods. Two Ground Rods MX–148/G supplied with each terminal or repeater set provide ground connection to the telephone terminal or to the repeater. The ground rods are 6 feet long.

i. Ground Rod Clamps. Two ground rod clamps are used to connect the ground lead to the ground rods.

j. Clamp TM–106. Clamp TM–106 is a soft copper ground clamp for ½- to 1¼-inch pipe. It connects the ground lead of the equipment to the pipe.

k. Junction Box JB–110. Junction Box JB–110 provides multiple outlets from the power unit, connecting a maximum of 10 two-conductor power cords to one power outlet. It consists of a five-gang box with cover and faceplates, housing five duplex convenience outlets. There is a 10-foot cord and plug wired into the box for connecting the box to the power outlet. Junction Box JB–110 is 4½ inches wide by 2¼ inches thick by 2¼ inches long, and the assembly weighs about 8½ pounds.

l. Case CS–111. Case CS–111 is a lead-lined carrying case for two batteries BB–55.

m. Chest BC–5. Chest BC–5 holds miscellaneous parts. The chest weighs 53 pounds.

14. Spare Parts

a. Telephone Terminal Set TC–21–(*). (1) A kit of running spares, including spare vacuum tubes and fuses, is shipped with Telephone Terminal Set TC–21–(*) in Package No. 8.

(2) Each power supply panel of Telephone Terminal CF–1–(*) mounts two spare 1-ampere fuses, two spare 10-ampere fuses, and one spare frequency generator. These are mounted in regular type receptacles which are not wired into the set.

(3) Four spare vacuum tubes are mounted on the line amplifier panel in unwired sockets.

(4) Spare fuses and vacuum tubes are also packed in the case with Telephone Terminal CF–1–(*).

(5) Four spare protectors are mounted on a rack at the top of the line coil and binding post panel at the top of the terminal bay.

(6) A spare lamp is mounted on the talk and signal panel.

b. Repeater Set TC–23–A. (1) Two spare vacuum tubes and seven spare 1-ampere fuses are packed in Package No. 3 of Repeater Set TC–23–A.

(2) Two spare 1-ampere fuses, two spare 10-ampere fuses, and a spare frequency generator are mounted on the power supply panel in regular type receptacles which are not wired into the set.

(3) Four spare vacuum tubes are mounted on the line amplifier panel in unwired sockets.

(4) Spare vacuum tubes and fuses are packed in the case with Repeater CF–3–A.

(5) Four spare protectors are mounted on a rack below the power supply panel at the bottom of the repeater bay.

15. Power Unit PE–201–(*)

In the past, some Power Units PE–201–(*) may have been issued as alternates to Power Unit PE–75–(*). When Power Unit PE–201 was issued, Rectifier RA–83–A was not required. However, a 50-foot Cord CD–712, used to convey power for charging batteries, is issued with Power Unit PE–201–(*). Power Unit PE–201–(*) is a gasoline-engine-driven generator producing 1,000 watts of 115-volt, 60-cycle power. The engine drives the generator at 1,800 rpm by means of dual V-belts. The generator may be used to produce 300 watts of 14.6-volt direct current. It may be used to supply both 60-cycle alternating current and 6- or 12-volt direct current at the same time. When supplying alternating current and direct current at the same time the generator will not produce its rated capacity. The complete unit weighs approximately 300 pounds and is about 19 by 38 by 24 inches over-all. A complete set of tools is provided with the unit. For a complete description and application of Power Unit PE–201–(*), see TM 11–914.

Note.—Power Unit PE–201–(*) refers to Power Unit PE–201–A, PE–201–B, or PE–201–C.

16. General Functioning of Telephone Terminal CF–1–(*) (Carrier)

The four circuits provided by the carrier system are designated channels 1, 2, 3, and 4. Panels are arranged on a bay for each of these channels. Each channel includes a transmitting and a receiving branch. These are combined on the voice-frequency side to form a two-wire circuit in the case of Telephone Terminal CF–1–A and to provide two-wire or four-wire operation in the case of Telephone Terminal CF–1–B. The change from two-wire to four-wire operation in Telephone Terminal CF–1–B is made by a key associated with each channel circuit. The controls and switches on the various panels of Telephone Terminal CF–1–(*) are described in paragraphs 17 to 26. More detailed information on the functioning of the equipment appears in section XIV.

17. Line Coil and Binding Post Panel

The binding posts by which connections to the line and other equipment are made are mounted

on this panel. The binding posts are insulated to minimize chance of shock when connections are made. This panel also mounts the protectors and drainage coils which protect the equipment against excessive external potentials which may be due to lightning surges or to power surges from nearby power lines. Retardation and repeating line coils are mounted on this panel.

18. Measuring Panel

A decibel meter marked DBM, a network controlled by a six-position switch, an OSC ON-OFF switch, a TRSG-REC key, and a CAL potentiometer switch are mounted on this panel.

a. DBM METER. The meter has an upper and a lower scale and is calibrated to measure power in dbm. The upper scale is used when

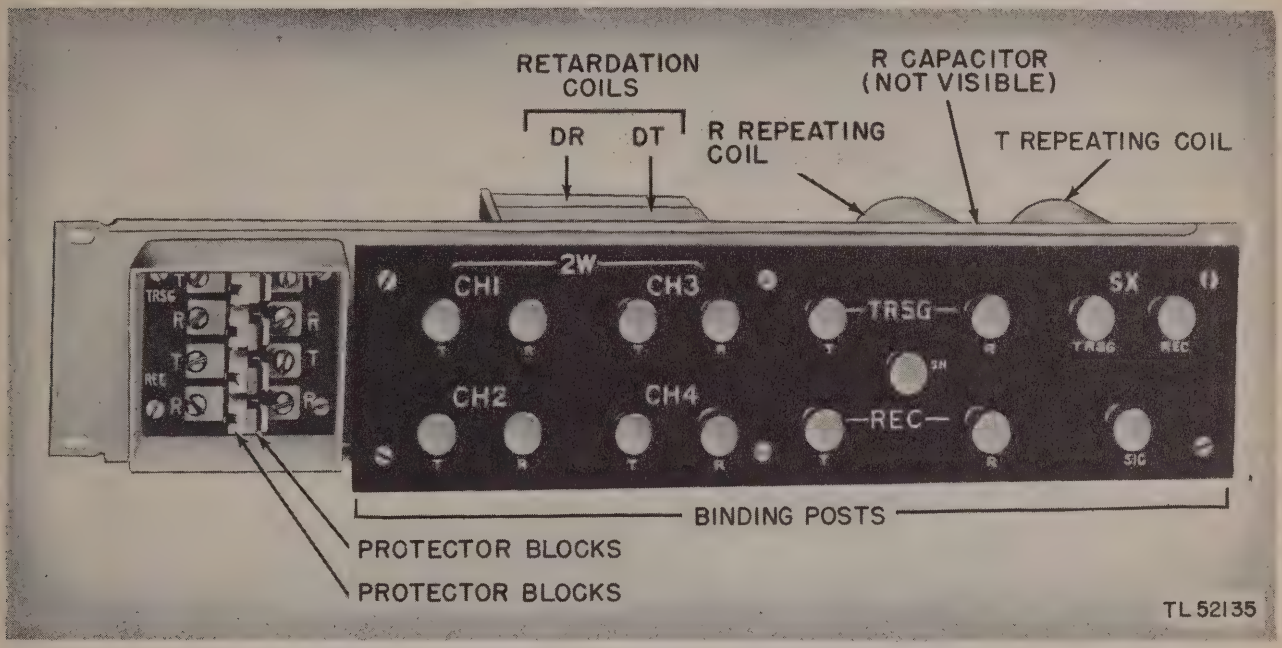


Figure 15. Telephone Terminal CF–1–A, line coil and binding post panel, front view.

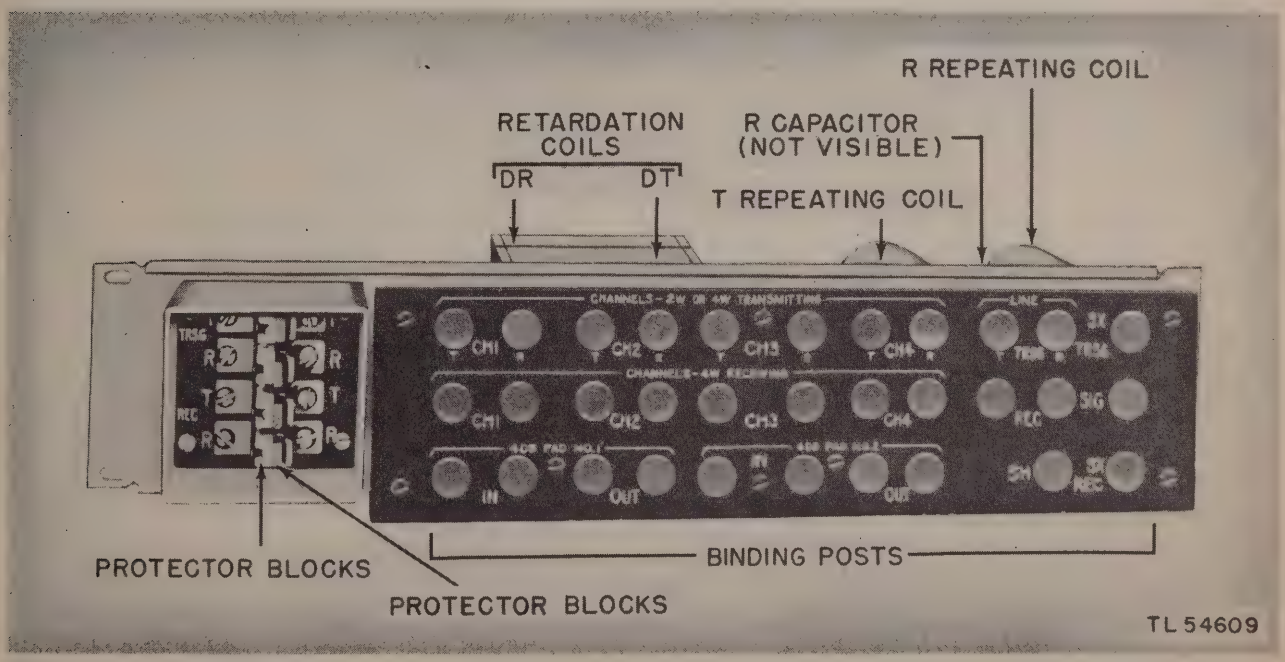


Figure 16. Telephone Terminal CF–1–B, line coil and binding post panel, front view.

adjusting the oscillator circuit output and the two-wire output and is calibrated in 1-db steps from 0 to −10 dbm and at the −12- and −20-dbm points. The lower scale is used in measuring the output of the transmitting and receiving amplifiers and is calibrated in 1-db steps from +5 to −5 dbm and at the −7- and −15-dbm points.

b. Six-position Switch. The switch position OSC connects the meter to the oscillator output. On Telephone Terminal CF–1–A there is a position marked 2W associated with the two-wire side of the hybrid coil. On Telephone Terminal CF–1–B this position is marked NET LOSS and is associated with the output of the channel amplifier. On both telephone terminals there are positions for each of the four selective networks. Each of these networks is tuned to one of the four channel testing frequencies given in tables XXXV to XLII in section XV. The network positions of the six-position switch are designated 1, 4, 2, and 3, corresponding to the order in which the panels are measured during the line-up procedure.

c. OSC ON-OFF Switch. The OSC switch is used to turn the oscillator ON or OFF. It is normally left in the OFF position to reduce the load on the power supply, particularly during battery operation.

d. TRSG-REC Key. When the TRSG-REC key is thrown to TRSG the output level of the transmitting circuit is measured. When it is thrown to REC, the input level of the receiving circuit is measured.

e. CAL Potentiometer. Also located on the measuring panel is a knob by which the CAL potentiometer is operated to adjust oscillator output. The panel is designed so that it is possible to measure the level of the test frequency in the output of the transmitting and receiving amplifiers for any channel while the other channels are in use.

19. Line Amplifier Panel

The line amplifier panel mounts the complete transmitting and receiving line amplifiers common to all channels.

20. Equalizer Panel

The equalizer panel mounts the adjustable networks and their control dials which are used for adjusting equalization to compensate for the attentuation characteristics of line sections.

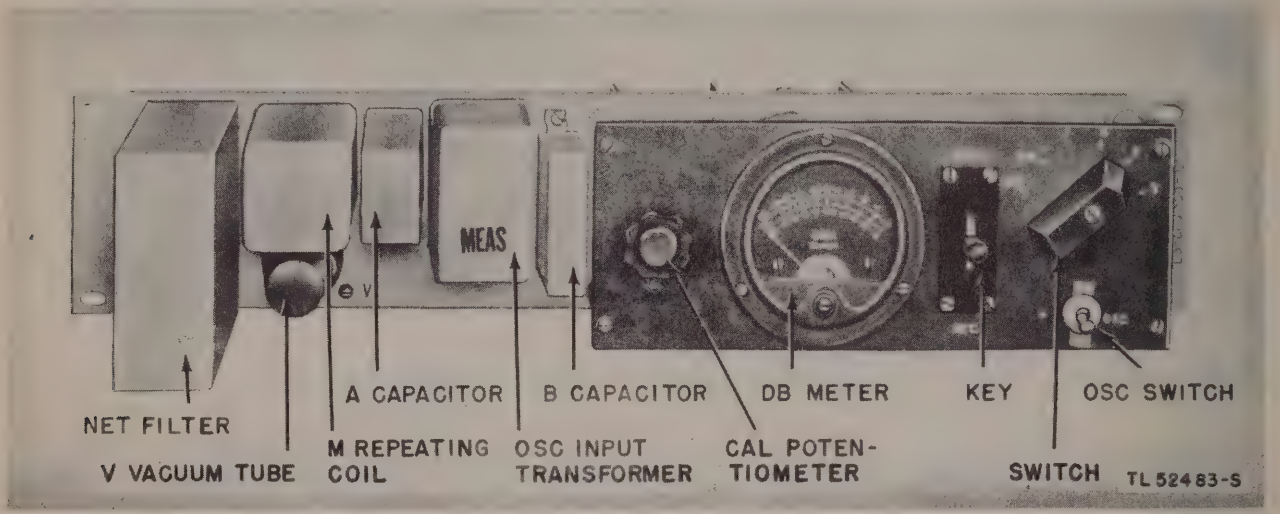


Figure 17. Telephone Terminal CF–1–A, measuring panel, front view.

a. MILES Dial. A MILES dial controls the low-frequency network and is adjustable in 5-mile steps from 0 to 30 miles.

b. Dial 1. Dial 1 controls the flat gain network and is adjustable in 1-db steps from 0 to 30 db.

c. Dial 4. The high-frequency network is controlled by dial 4, which is adjustable in 1-db steps from 0 to 14 db.

d. Dial 2. Dial 2 controls the midfrequency network and is adjustable in 1-db steps from 0 to 8 db. All of these dials are marked to correspond to the channel on which test power is measured when making adjustments.

e. Chart. A chart indicating approximate settings of the dials for various lengths is mounted on the panel. Space is provided on the chart for keeping a record of the operating dial settings and the line-up of the system. Minor adjustments

of the equalizer may be made while the system is in service.

21. Channel 1 Panel

Channel 1 panel contains the equipment, controls, and switches for the transmitting and receiving circuits for one telephone circuit. This channel utilizes the voice frequencies.

a. SEND KEY. The SEND key is arranged to connect the testing power directly to channel 1. When operated, this key disconnects the transmitting branch from the hybrid coil and connects the 1,000-cycle testing power from the test oscillator to the transmitting branch.

b. MEAS KEY. Operation of the MEAS key terminates the channel in the transmission measuring circuit for measuring the test power received over channel 1.

c. GAIN POTENTIOMETER. The GAIN potentiometer settings indicate the gain of the voice-frequency amplifier. The potentiometer is adjustable in 1-db steps from 12 to 30 db with two additional steps of 37.5 and 45 db.

d. TALK-MON KEY. The TALK-MON key

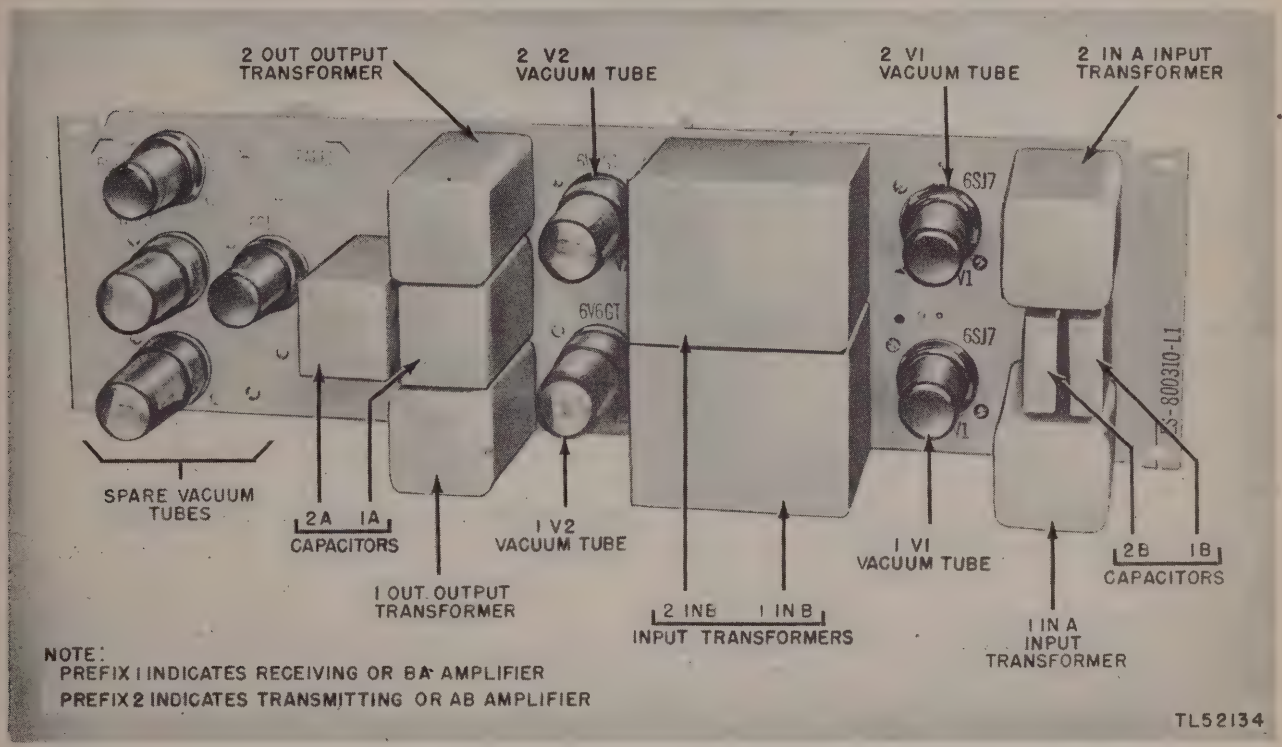


Figure 18. Telephone Terminal CF–1–(*) and Repeater CF–3–A, line amplifier panel, front view.

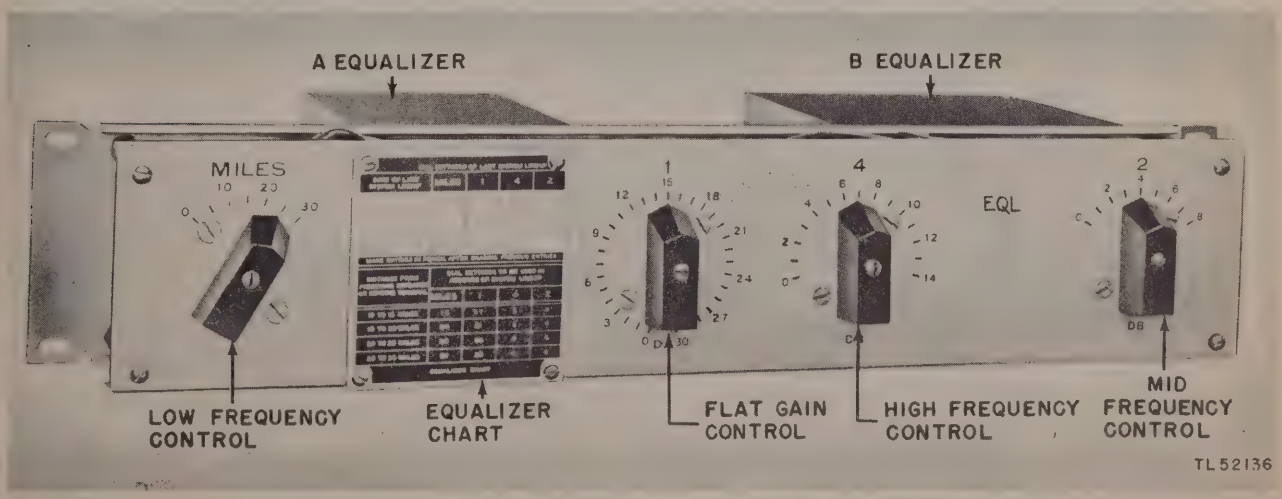


Figure 19. Telephone Terminal CF–1–(*), equalizer panel, front view.

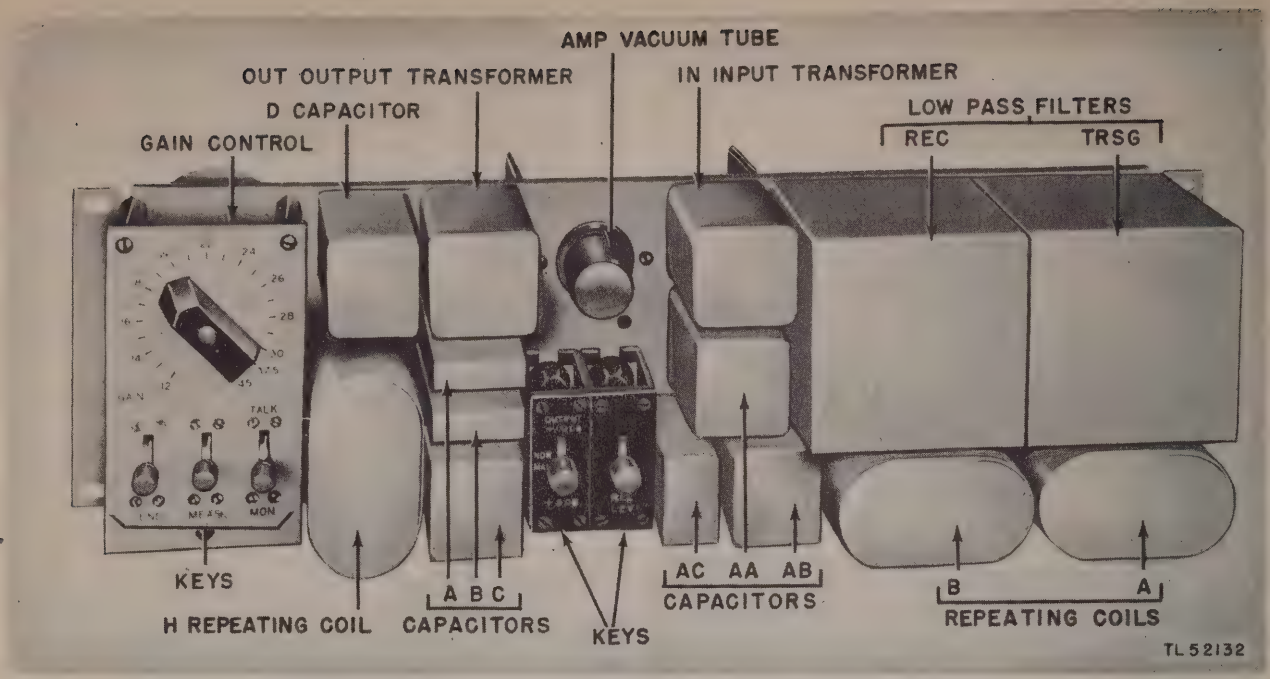


Figure 20. Telephone Terminal CF–1–A, channel 1 panel, front view.

is arranged to connect the channel 1 circuit to the TEL binding posts on the talk and signal panel on Telephone Terminal CF–1–A or the talk and monitor circuit of Telephone Terminal CF–1–B. In Telephone Terminal CF–1–A there is a connection on the talk and signal panel for a field telephone. In Telephone Terminal CF–1–B there is a built-in talking and monitoring circuit, making the connection of a field telephone unnecessary. When the TALK-MON key is operated to TALK, the telephone is connected to channel 1 for communication. When the key is operated to MON, a high-impedance monitoring circuit is inserted between the telephone and channel 1. With the switch in this position, monitoring can be carried on from the telephone, causing little loss in the telephone circuit on channel 1.

e. OUTPUT KEY. The OUTPUT key is a

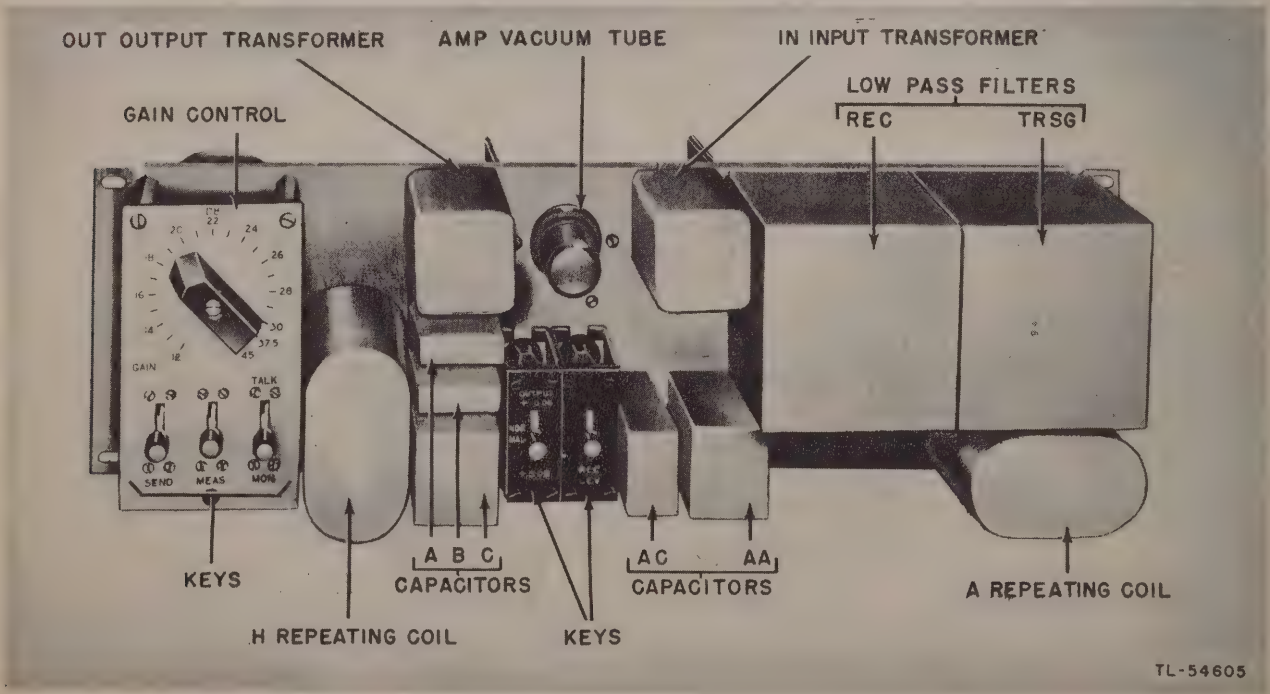


Figure 21. Telephone Terminal CF–1–B, channel 1 panel, front view.

part of the common transmitting and receiving circuit of channels 1, 2, 3, and 4. The key is used to control the output level of the common transmitting branch. The OUTPUT key also controls pads in the transmission measuring circuit to facilitate measuring the power delivered to the cable for the three settings of the key. The key is equipped with a guard to prevent accidental operation. It may be locked in any one of its three positions.

22. Channels 2, 3, and 4 Panels

Channels 2, 3, and 4 differ from channel 1 in that the speech currents are shifted by modulation for transmission over the line and require demodulation at the receiving terminal to convert the carrier-frequency band back to voice frequency. Channels 2, 3, and 4 are alike except for an oscillator tuning capacitor E, for filters TRSG 2 and REC 1, and for the pad formed by resistors E, F, and G. Channels 2, 3, and 4 terminate on the

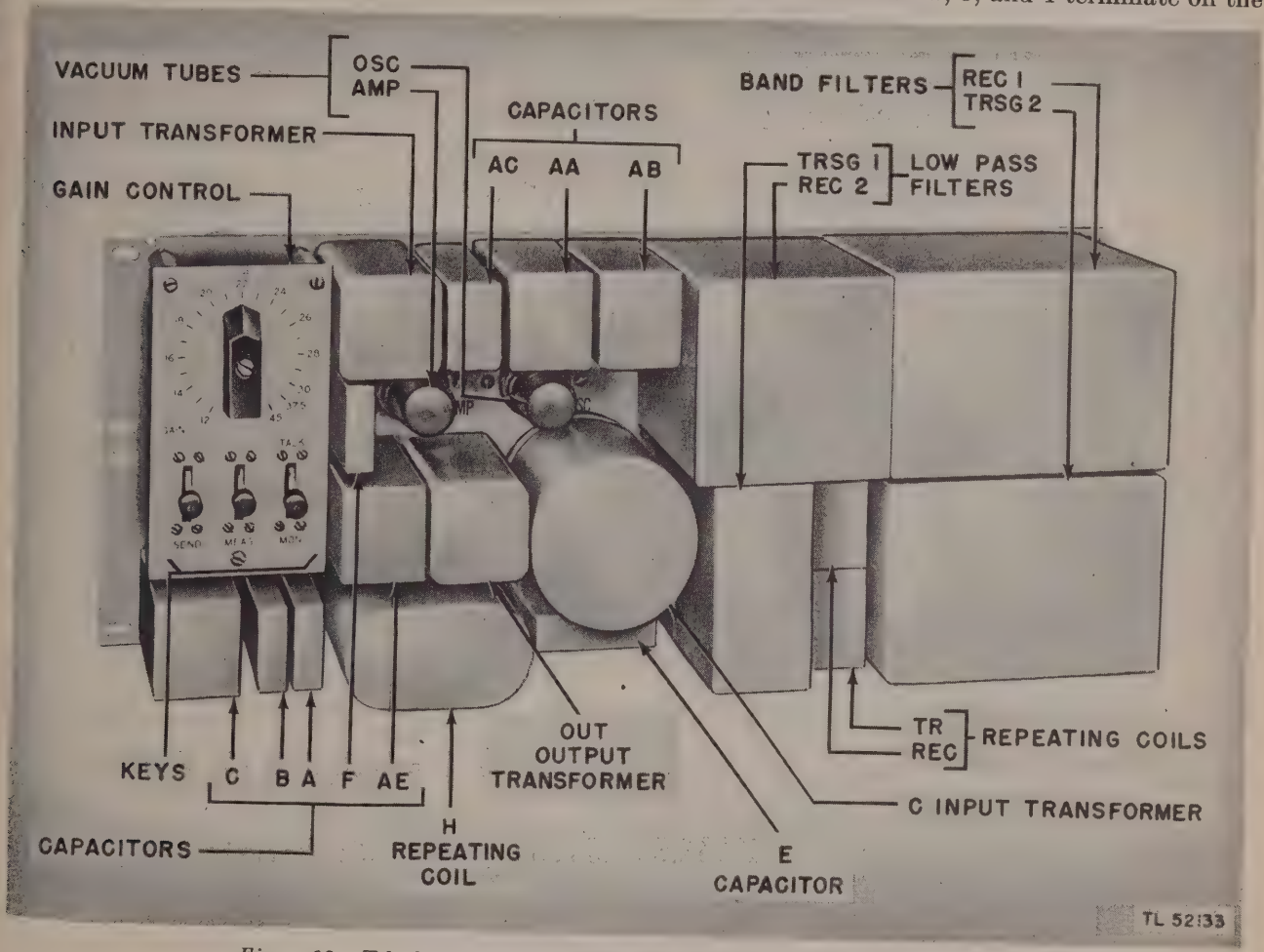


Figure 22. Telephone Terminal CF–1–A, channel 2, 3, or 4 panel, front view.

f. REC LEV KEY. The REC LEV key is also a part of the common receiving circuit of channels 1, 2, 3, and 4. Operation of the REC LEV key removes a 10-db pad from the receiving circuit, affording additional gain. This is useful in maintaining service in the case of trouble in the line which results in the received power being abnormally low. A guard on the REC LEV key locks it in place and prevents false operation. The key may be locked in either its normal or operated position.

binding posts designated CH2, CH3, and CH4 on Telephone Terminal CF–1–A. When Telephone Terminal CF–1–B is terminated on a two-wire basis these channels terminate on CH2, CH3, and CH4 CHANNELS-2W or 4W TRANSMITTING binding posts. When Telephone Terminal CF–1–B is terminated on a four-wire basis, the transmitting branch terminates on the CH2, CH3, and CH4 CHANNELS-2W or 4W TRANSMITTING binding posts and the receiving branch terminates on the CH2, CH3, and CH4

CHANNELS-4W RECEIVING binding posts. The channels 2, 3, and 4 panels have keys similar to those on the channel 1 panel, and they perform the same functions as the keys on channel 1.

a. SEND AND MEAS KEYS. The SEND and MEAS keys on channel 3 are provided with key guards to prevent accidental operation which would cause an interruption to telegraph operation, normally used on channel 3.

b. TALK-MON KEY. The TALK-MON key on each of these channel panels connects the field telephone set used with Telephone Terminal CF–1–A or the built-in monitoring circuit on Telephone Terminal CF–1–B in the same way as for channel 1. On the channel 3 panel this key is equipped with a guard to prevent accidental operation.

c. GAIN POTENTIOMETER. The GAIN potentiometer performs the same function as on channel 1.

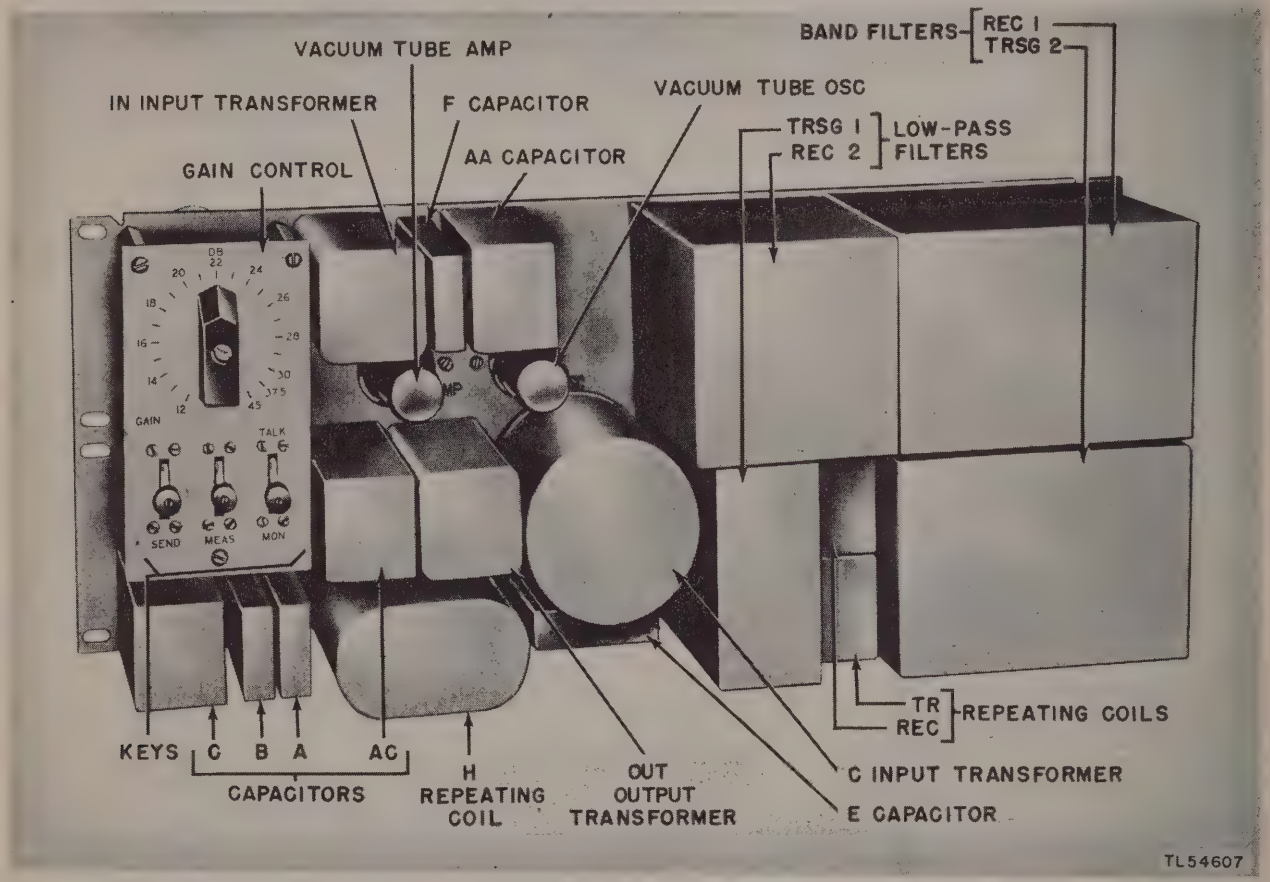


Figure 23. Telephone Terminal CF–1–B, channel 2, 3, or 4 panel, front view.

23. Signal Panel (Telephone Terminal CF–1–A)

Each Telephone Terminal CF–1–A is provided with alarm and signaling equipment arranged to be connected to one of the simplex circuits. A line-relay SIGNAL key, bell, lamps, SIGNAL CUTOFF key, BATTERY-GROUND key, and TEL binding posts are mounted on the signal panel.

a. BATTERY-GROUND KEY. The BATTERY-GROUND key is provided for applying either battery or ground for the operation of the signal and alarm circuit.

b. SIGNAL KEY. Operation of the SIGNAL key at any point rings a bell at each terminal and intermediate repeater. The alarm and signaling circuit is used for communication and maintenance and for indicating line failures.

c. SIGNAL CUTOFF KEY. If a break occurs in the line, the bells will ring until silenced by operation of the SIGNAL CUTOFF keys. When the line is restored to operation, the bells again sound until they are silenced by returning the SIGNAL CUTOFF keys to their normal positions. If the line is open for an appreciable length of time, communication between terminals and repeaters may be partially restored by terminating the alarm and signaling circuit to ground at the repeaters on each side of the break.

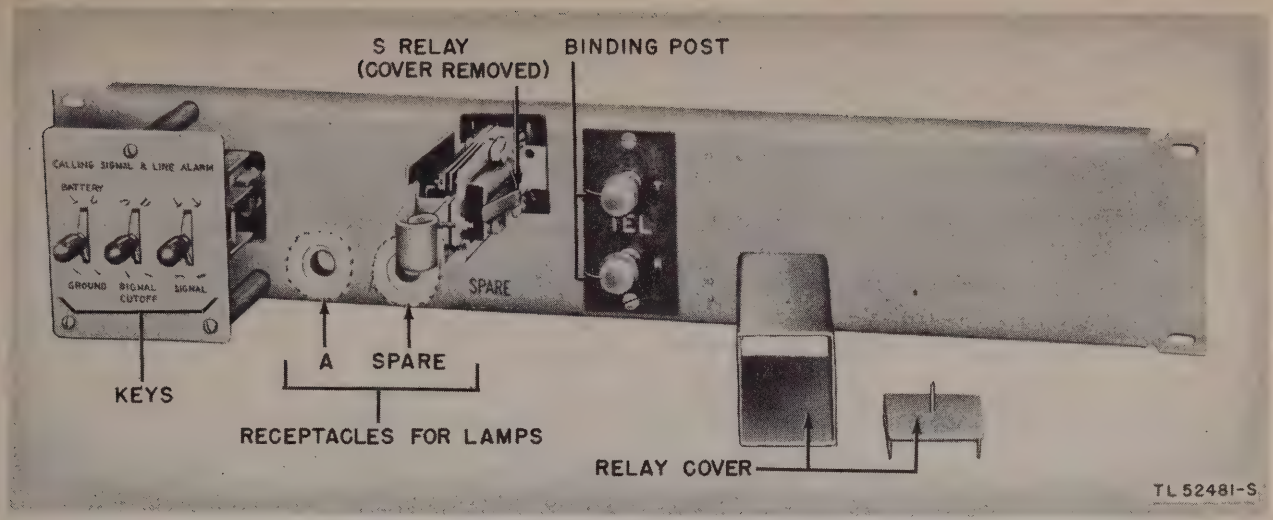


Figure 24. Telephone Terminal CF–1–A, signal panel, front view.

d. 3-WATT LAMP. The 3-watt lamp limits the maximum current and also serves to indicate when battery is being supplied. A spare lamp is provided in the SPARE socket.

e. TEL BINDING POSTS. TEL binding posts are located in the center of the signal panel on Telephone Terminal CF–1–A for connection of a field telephone for talking and monitoring.

24. Talk and Signal Panel (Telephone Terminal CF–1–B)

The alarm and signaling circuit of Telephone Terminal CF–1–B is identical to that of Telephone Terminal CF–1–A. Telephone Terminal CF–1–B has a built-in talking and monitoring circuit, however, so that no Tepehone EE–8–(*) is required for the operator and no TEL binding posts are provided. The CHANNEL TERMINATION keys are mounted on this panel.

a. SIGNAL KEY, SIGNAL CUTOFF KEY, AND BATTERY-GROUND KEY. A SIGNAL key, SIGNAL CUTOFF key, and BATTERY-GROUND key with the same functions as those on Telephone Terminal CF–1–A are mounted on the CALLING SIGNAL & LINE ALARM panel on the left-hand side of the talk and signal panel.

b. TEL KEY. The circuits from the SIGNAL, SIGNAL CUTOFF, and BATTERY-GROUND keys are bridged into a common talking circuit controlled by the two-position TEL key. The LINE or 2W SWBD position connects the circuit for talking over a channel toward the opposite terminal or to the switchboard when the

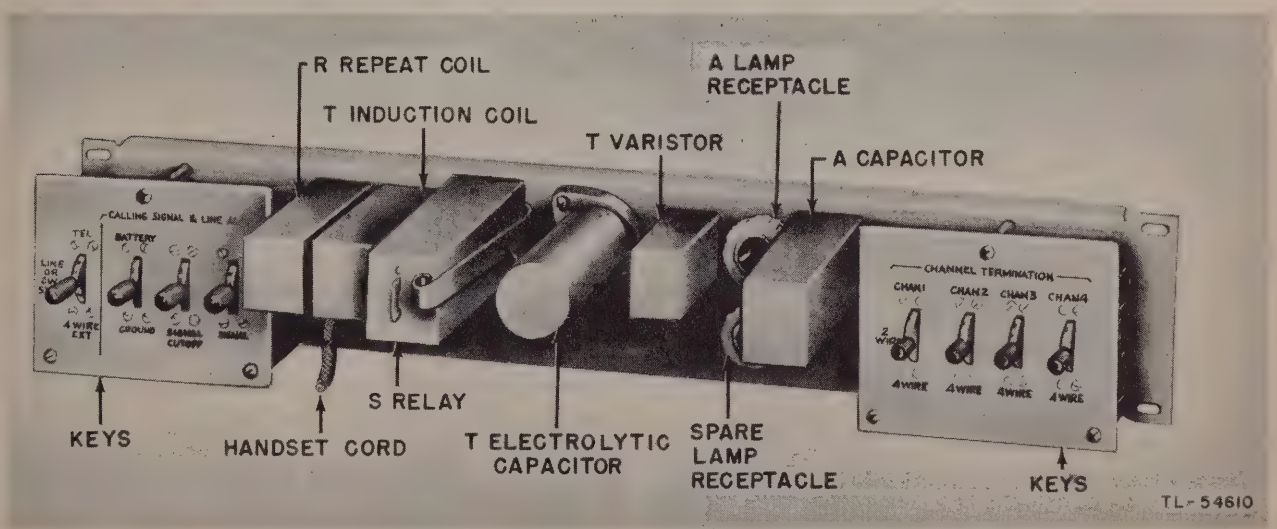


Figure 25. Telephone Terminal CF–1–B, talk and signal panel, front view.

channel is terminated on a two-wire basis, or for talking over the carrier system to the opposite terminal when the channel is terminated on a four-wire basis. The 4 WIRE EXT position is used for talking over the circuit when the channel is terminated on a four-wire basis.

c. HANDSET. The handset provided with the terminal is equipped with a push-to-talk key. The handset cord enters the panel just below repeat coil R and induction coil T.

d. CHANNEL TERMINATION KEYS. Keys for CHAN 1, CHAN 2, CHAN 3, and CHAN 4 **2 WIRE or 4 WIRE terminations** are mounted on the CHANNEL TERMINATION panel on the right-hand side of the talk and signal panel. With the channel key in the 2 WIRE position the receiving circuit is connected to hybrid coil H, passes through the hybrid coil, and is terminated at the CHANNELS-2W or 4W TRANSMITTING binding posts T and R in the same manner as Telephone Terminal CF–1–A. In the 4 WIRE position this key disconnects the receiving circuit from hybrid coil H, terminates it in binding posts of CHANNELS-4W RECEIVING, and places a 300-ohm resistor N1 across the receiving leads of hybrid coil H.

25. Spare Tube Panel

A spare tube panel is located just below the talk and signal panel. There are unwired sockets for mounting eight spare vacuum tubes.

26. Power Supply Panels A and B

a. The power supply panels A and B for Telephone Terminals CF–1–A and CF–1–B are now identical. However, power supply panels for models of Telephone Terminal CF–1–A with serial numbers below 380 differ slightly from those for later models of Telephone Terminal CF–1–A and for Telephone Terminal CF–1–B. (See par. 36*d*.) These panels, located at the bottom of the terminal bay, supply the operating voltages. Together they require 60 watts of 115- to 230-volt, 50- to 60-cycle a-c power, or a **12-volt storage battery.**

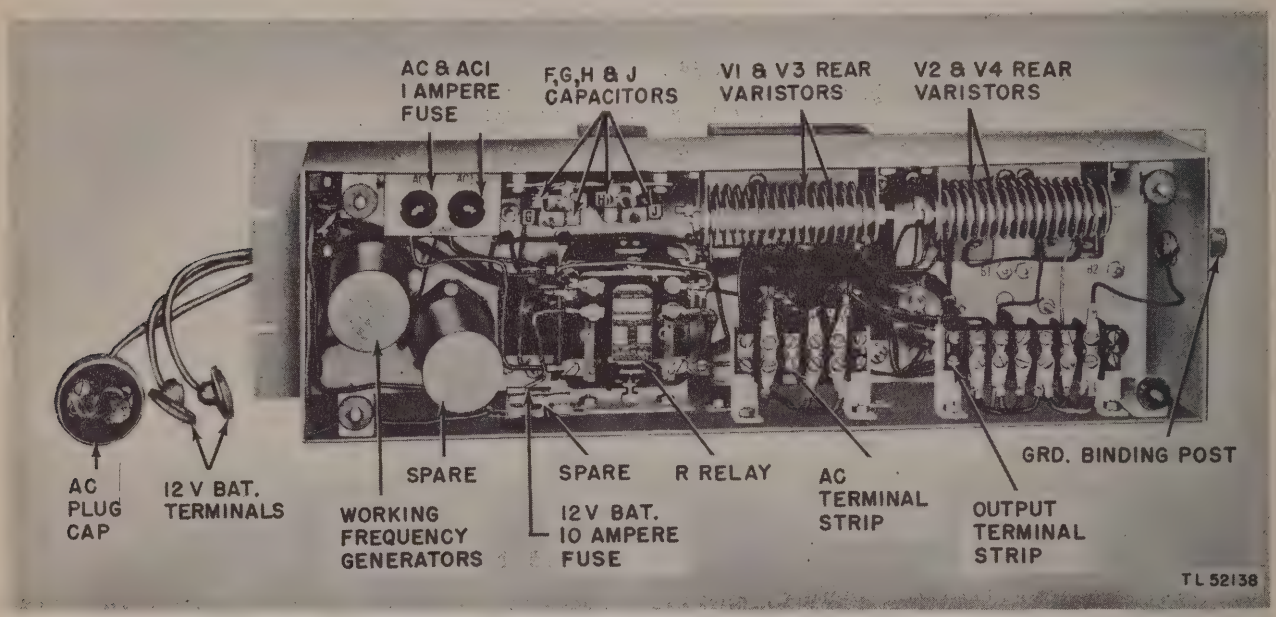


Figure 26. Telephone Terminal CF–1–A (serial numbers below 380), power supply panel, front view.

b. Two identical power circuits are provided: PWR SUP A supplies the transmitting and receiving amplifiers and the signal and alarm circuit, while PWR SUP B supplies the channel and measuring circuits. Figures 64 and 65 are schematic diagrams of power supply panels.

c. A 30-inch cord terminating in a plug is provided with each power supply panel for connections to multiple a-c supply outlets located at the base of the bay. There are six outlets. Two are required for the two power supply panels. The other four outlets are provided for convenience and may be used to supply a-c power to other units, such as ringers, on the same a-c supply main. An 8-foot cord, designated AC and terminated in a plug at one end and in the multiple outlets at the other, is for connection to the external a-c supply main.

d. **Both sides of the a-c supply are provided** with 1-ampere fuses. Two spare 1-ampere fuses are mounted on the inside of the front cover of the panel.

e. A 6-foot cord designated 12V BAT and equipped with battery terminals is for connection to storage batteries. A lug marked 12V+ is for connection to the positive terminal of the battery, and the lug marked 12V— is for connection to the negative terminal of the battery. Normally a separate 12-volt storage **battery unit made up of** two 6-volt batteries connected in series is used for each power supply panel. The positive 12-volt tap is grounded on the panel. The negative and positive leads from the 12-volt battery each have a 10-ampere fuse. Two spare 10-ampere fuses are mounted inside the front cover of the power supply panel.

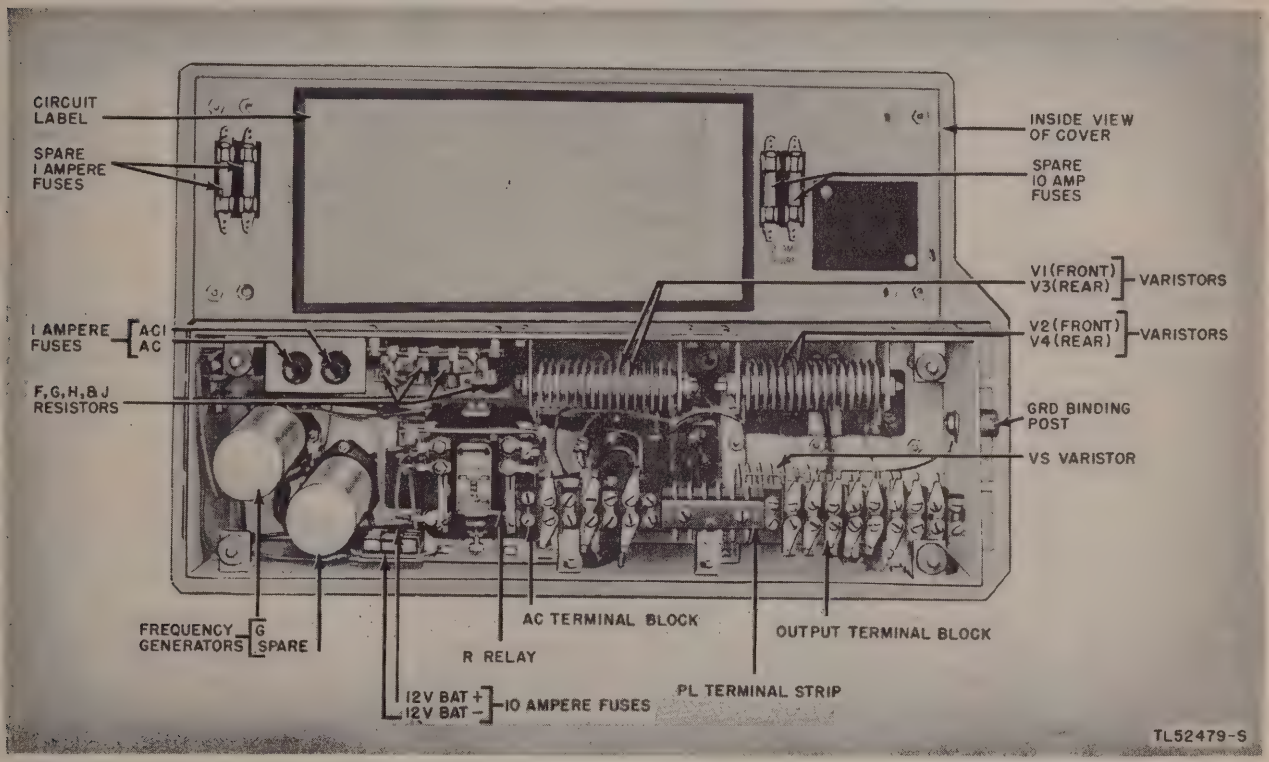


Figure 27. Telephone Terminal CF–1–A (serial numbers 380 and above) and Telephone Terminal CF–1–B, power supply panel, front view.

27. General Functioning of Repeater CF–3–A (Carrier)

The repeater is used to extend the length of the system and is composed of two independent amplifying circuits. One circuit is associated with the A to B direction of transmission, and the other is associated with the B to A direction of transmission. The controls and switches on the panels of Repeater CF–3–A are described in paragraphs 28 to 32. More detailed information on the functioning of the system appears in section XIV.

28. Measuring and Binding Post Panel

Figure 28 shows the front view of the measuring and binding post panel.

a. MEAS KEY. The MEAS key, mounted in the lower left-hand corner of this panel, permits connecting the measuring circuit to the output of the amplifier in the A to B or in the B to A direction of transmission.

b. MEAS 1-4-2-3 SWITCH. The MEAS 1-4-2-3 switch is a four-position selecting switch which connects the meter to the output of the amplifier.

c. DBM METER. A meter, designated DBM, is identical to the one used at a terminal, but at the repeater only the portion of the lower scale between −5 to +5 dbm is used.

d. OUTPUT KEY. The OUTPUT key has three positions, designated NORMAL, +5DB, and +10DB, to control the output level.

e. BINDING POSTS. At the top of the panel are binding posts for the two directions of transmission and SX binding posts for connection to the simplex circuit. The binding posts are insulated

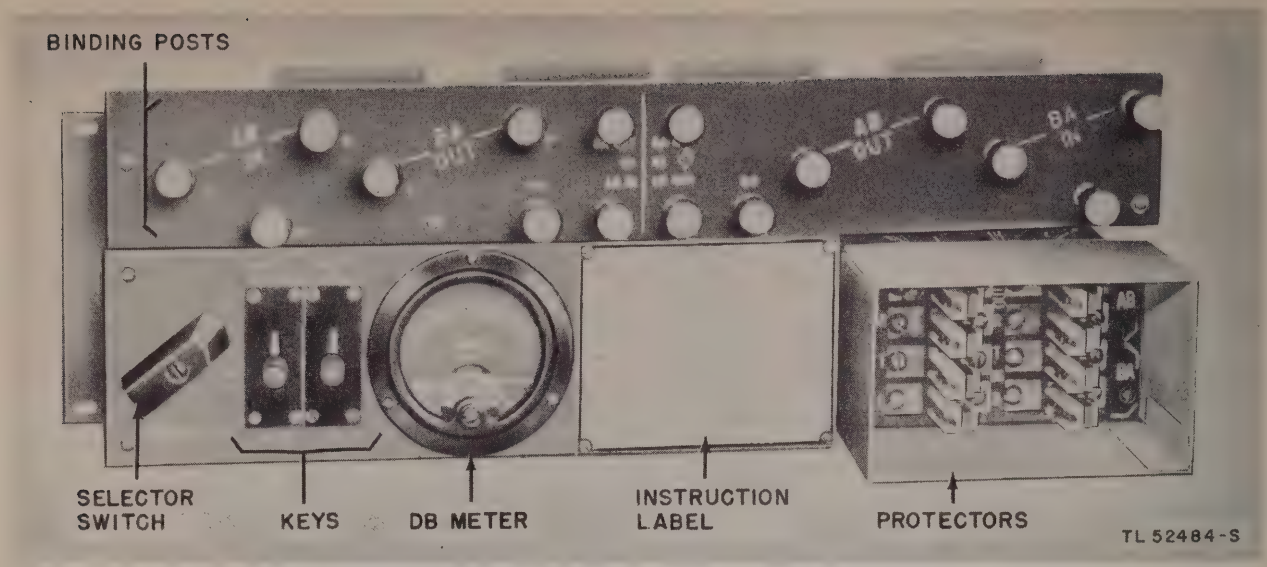


Figure 28. Repeater CF–3–A, measuring and binding post panel, front view.

to minimize possible chance of shock when connections are made.

f. CHART. A chart of condensed instructions is mounted in the center of the panel. Protectors are located in the lower right-hand corner.

29. Equalizer Panels

Each repeater has two equalizer panels. These panels are identical with the equalizer panel on the terminals.

a. EQL AB PANEL. The EQL AB panel is located directly below the measuring and binding post panel. By means of the equipment mounted on the AB equalizer panel, compensation for transmission attenuation characteristics is adjustable at the repeater in the direction from terminal A to terminal B.

b. EQL BA PANEL. The EQL BA panel is located below the line amplifier panel. By means of the equipment mounted on the BA equalizer panel, compensation for transmission attenuation characteristics is adjustable at the repeater in the direction from terminal B to terminal A.

30. Line Amplifier Panel

The line amplifier panel mounts the equipment for the line amplifiers in both the AB and BA directions. Each amplifier has a fixed gain of 50 db. The line amplifiers in the repeaters are identical with the common transmitting and receiving amplifiers in the terminals.

31. Talk and Signal Panel

Figure 29 shows a front view of the talk and signal panel at Repeater CF–3–A. As at a terminal, a

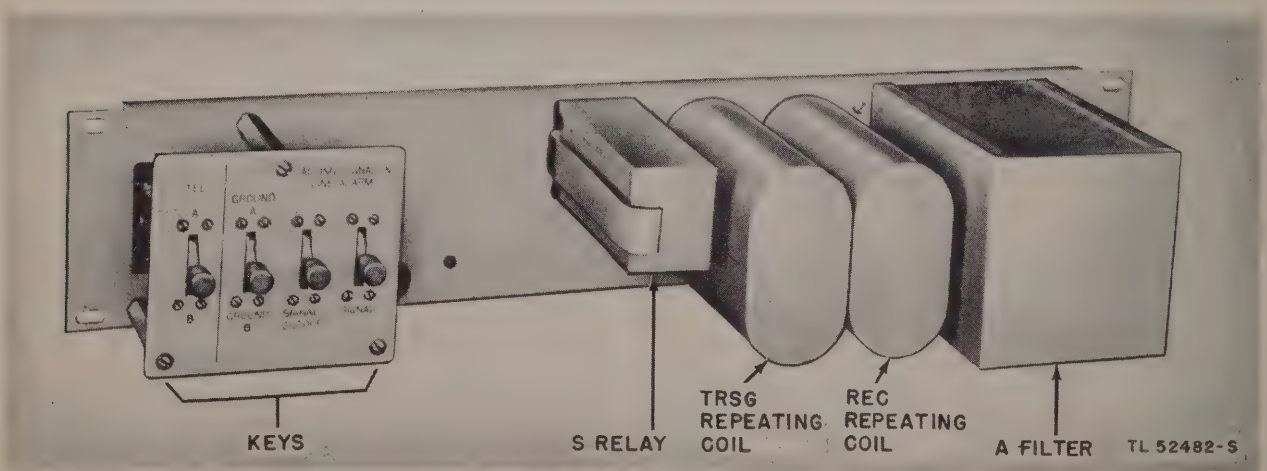


Figure 29. Repeater CF–3–A, talk and signal panel, front view.

repeater has a line relay, SIGNAL key, bell, and SIGNAL CUTOFF key mounted on the panel. There is also a GROUND A-GROUND B key to provide a ground termination for partially restoring communication between terminals and repeaters if the line is open for a length of time, and a TEL A-B key. The alarm and signaling circuit terminates at a repeater in binding posts SA and SB. These binding posts are located on the panel at the top of the bay and the equipment is mounted on the talk and signal panel.

a. SIGNAL KEY. Operation of the SIGNAL key rings a bell at each terminal and intermediate repeater.

b. SIGNAL CUTOFF KEY. Operation of the SIGNAL CUTOFF key silences the bell which sounds when a break occurs in the line. When the line is restored to operation the bell again sounds. It may be silenced by returning the SIGNAL CUTOFF key to its normal position.

c. GROUND A-GROUND B KEY. The two-position ground key is used to provide a ground termination of the alarm and signaling circuit on each side of a break in the line so that communication may be partially restored. If the break is toward terminal A position, A is used, and if toward terminal B position, B is used.

d. TEL KEY. The three-position TEL key selects the direction of call for talking and monitoring over channel 1. In the normal position the handset, which is permanently mounted on the bay for communication over channel 1, is disconnected from the circuit. In the A position the handset is connected for communication with terminal A or with repeater toward terminal A. In the B position the handset is in condition for communication with terminal B or with repeaters toward terminal B.

32. Power Supply Panel

The power supply panel which is located at the bottom of the bay is identical with the power supply panels at a terminal. Power supply requirements for a repeater are the same as those for a terminal except that only one power supply panel is provided at a repeater. Four spare protectors are mounted directly below the power supply panel at the bottom of a bay.

33. Electrical Characteristics of Telephone Terminal CF–1–(*).

a. Each carrier system is composed of two Telephone Terminals CF–1–A or CF–1–B with the number of intermediate repeaters necessary to complete the circuit. The carrier system is constructed by placing a telephone terminal at each end of the system with the intermediate repeaters spaced at intervals of approximately 25 miles each. For systems of 45 miles or less repeaters are not required when spiral-four cable is used.

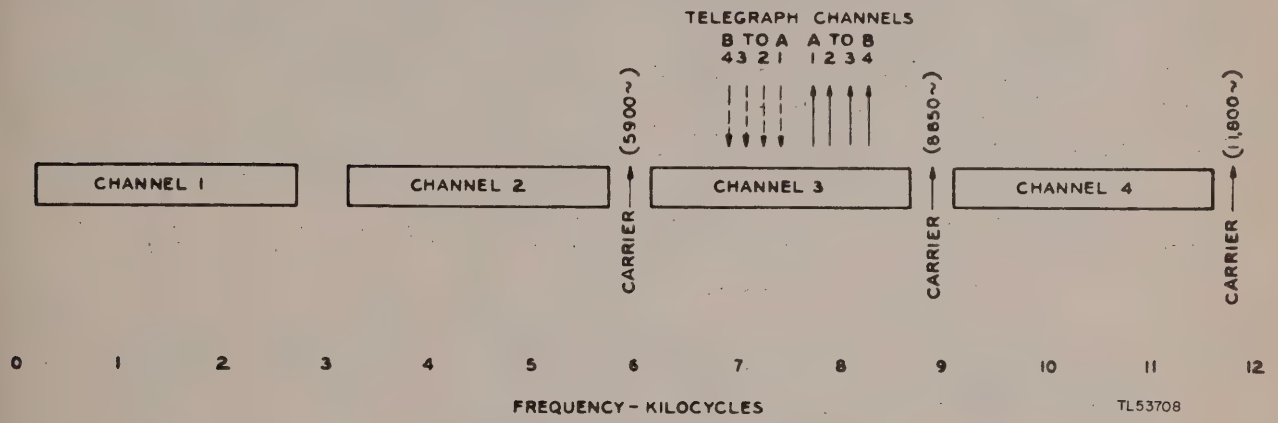


Figure 30. Frequency allocation chart.

b. Figure 30 shows the frequency bands used by a four-channel carrier system using either Telephone Terminal CF–1–A or CF–1–B. Channel 1 covers the voice-frequency band and channels 2, 3, and 4 are carrier-frequency channels. Each of the four channels carry frequencies of about 2,600 cycles in width. Channel 1 passes audio frequencies of 0 to 2,600 cycles. The audio-frequencies of channels 2, 3, and 4 are modulated and superimposed on the carrier frequencies of the channel they are being sent over. When a voice-frequency carrier telegraph system is used in conjunction with a carrier telephone system, it will normally be operated over channel 3 as indicated in figure 30. The solid arrows represent the frequencies of the four telegraph circuits for

one direction of transmission and the dotted arrows for the other direction. The telegraph circuit frequency arrangement shown is that of Telegraph Terminal CF–2–A or CF–2–B.

c. The power existing at certain points in the circuit for each channel, assuming that 1,000-cycle power of 1 milliwatt is applied to the two-wire side of the hybrid coil, is shown in figure 31. One milliwatt is also the amount of power used in testing and maintaining this system. The values are expressed in dbm which denotes the power in decibels above or below 1 milliwatt. The minus sign is used to denote power below 1 milliwatt.

d. In Telephone Terminal CF–1–B each channel includes a transmitting and receiving branch which may be combined to form a two-wire circuit on the voice-frequency side as in Telephone Terminal CF–1–A, or which may be terminated to form a four-wire circuit. A compromise network consisting of 600 ohms and 0.6 microfarads is used to balance a line or the subset connected to the two-wire circuit. Channel 1 includes a voltage limiter in the transmitting side to prevent loud talkers on that channel from overloading the common system amplifier and interfering with talkers on the other channel. Channels 2, 3, and 4 include a modulator and oscillator for translating the voice frequencies into the carrier frequency band for transmission over the cable. These modulators also limit the voltage obtained from loud talkers.

e. The transmitting sides of each of the four channels are combined at the output of the channel filters and amplified by a common transmitting amplifier for transmission over the transmitting line pair. The power delivered to the line with 1 milliwatt applied to the two-wire input of the terminal is normally 0 dbm on each channel. A key-controlled pad is provided ahead of the transmitting amplifier to permit increasing the output to either +5 or +10 dbm to extend the range of a carrier system which uses no repeaters. This key-controlled pad is also used in the case of a temporary excessive noise condition on the carrier system.

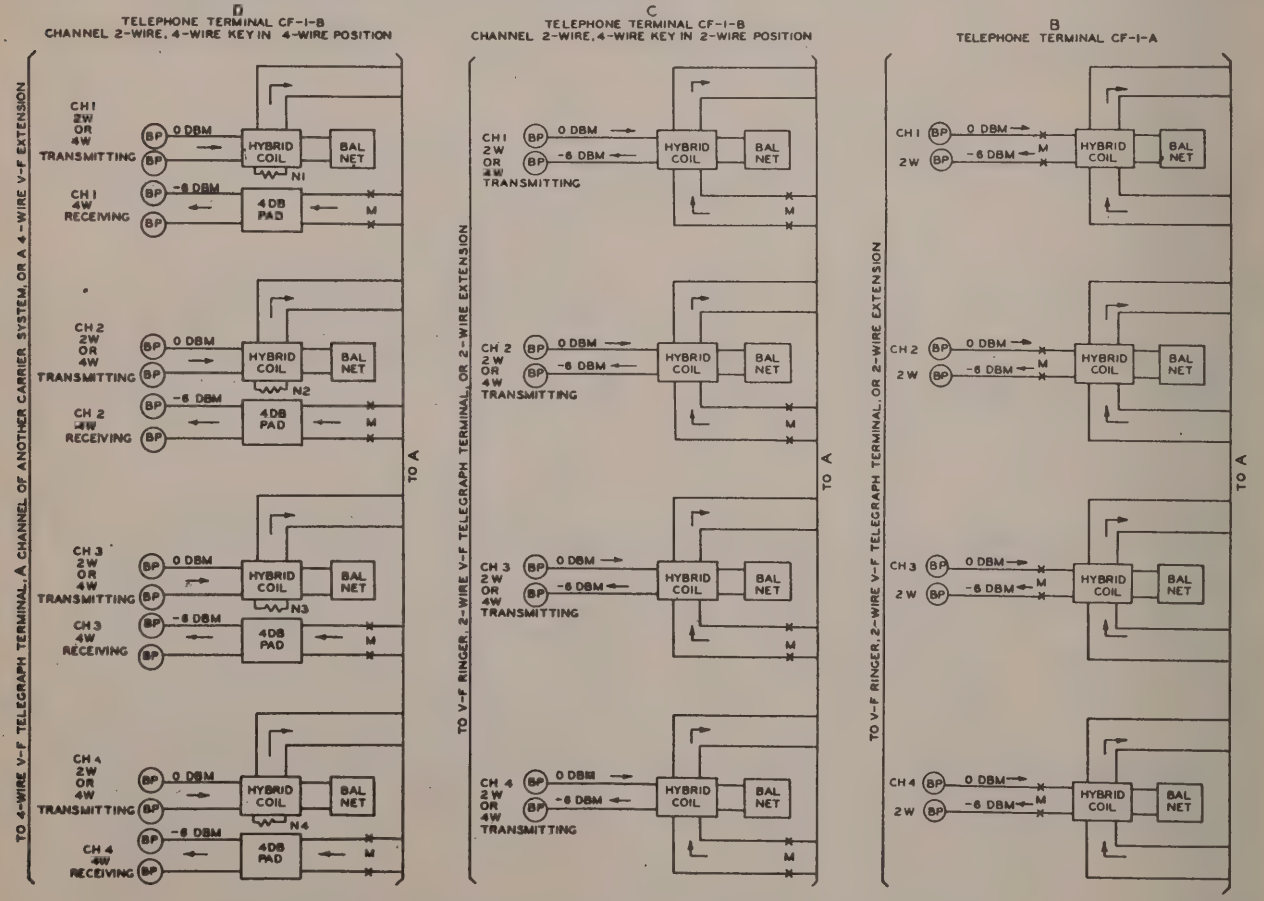


Figure 31. Telephone Terminal CF–1–(*), block schematic diagram.

f. In the receiving direction a common receiving circuit provides the equalization and gain for the preceding line section. The frequencies of the four channels pass through the common receiving amplifier and a key-controlled 10-db pad. They are then separated by filters which pass through to each channel receiving circuit the frequency assigned to the channel. The 10-db pad permits increasing the common receiving gain by 10 db when required.

g. Channels 2, 3, and 4 each include a demodulator and oscillator which translate the carrier frequencies back to voice frequencies for each channel. The oscillator is common to the transmitting and receiving branches of each channel. A voice-frequency amplifier is included in the circuit of each channel. The gain of this amplifier is adjusted to obtain the desired over-all circuit net loss of each channel. The hybrid coil in each channel separates the signal being transmitted in one direction from the signal being received in the other direction when a two-wire termination is used.

h. Testing power of 1,000 cycles is provided at the terminal for use in line-up and maintenance of the system. Testing power of —4 dbm is applied to the channels at the points marked S in figure 31, and the power which should be obtained is indicated in other points in the circuit. Measuring equipment is included for indicating the testing power at the points in figure 31 marked M.

i. Talking and monitoring at Telephone Terminal CF–1–A requires a field telephone set external to the equipment. In Telephone Terminal CF–1–B, however, there is a built-in handset. Key arrangements are included in the channels for connecting the telephone set which has to be used with Telephone Terminal CF–1–A to

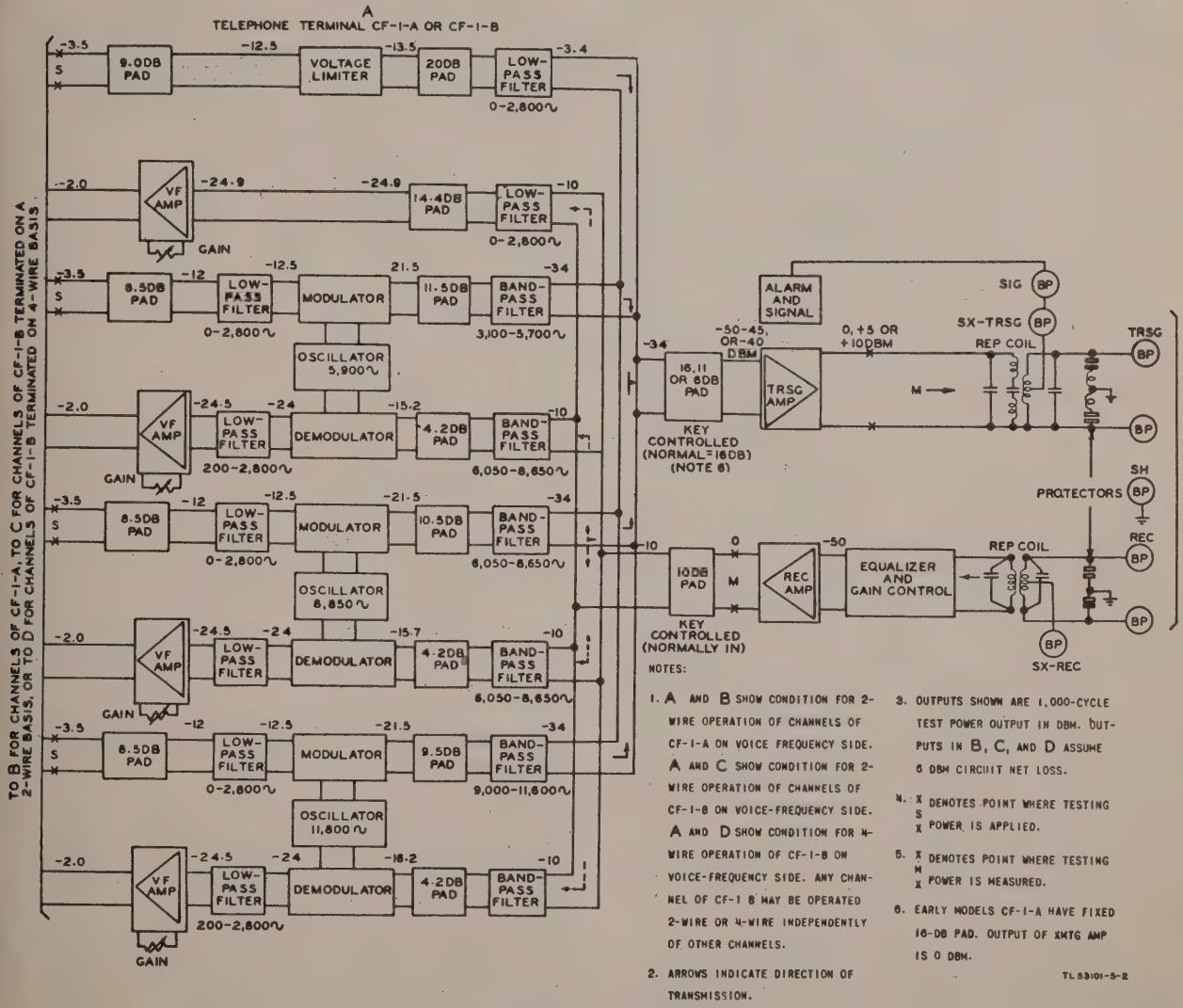


Figure 31—Continued.

any one of the four channels. Channel 1 will normally be used for servicing of the system since it is the only channel which can be used for talking at intermediate repeaters.

j. Each terminal is provided with alarm and signaling equipment arranged to be connected to one of the simplex circuits. A bell, a SIGNAL key, and a SIGNAL CUTOFF key are provided for signaling intermediate repeaters and the distant terminal.

k. Two identical power supply circuits are provided which together require 60 watts of 115- or 230-volt, 50- to 60-cycle, a-c power, or two

is associated with the A to B direction of transmission and the other with the B to A direction. A gain-adjusting equalizer, which is identical to the one provided in the common receiving circuit at the terminal, is provided in each amplifying circuit. After the signals pass through the equalizers of their respective channels they then go to the amplifiers which boost the signals received at the repeater to the same db level at which they left the transmitting terminal.

b. A handset is provided for communicating over channel 1. The alarm and signaling circuit is similar to that provided at the terminal.

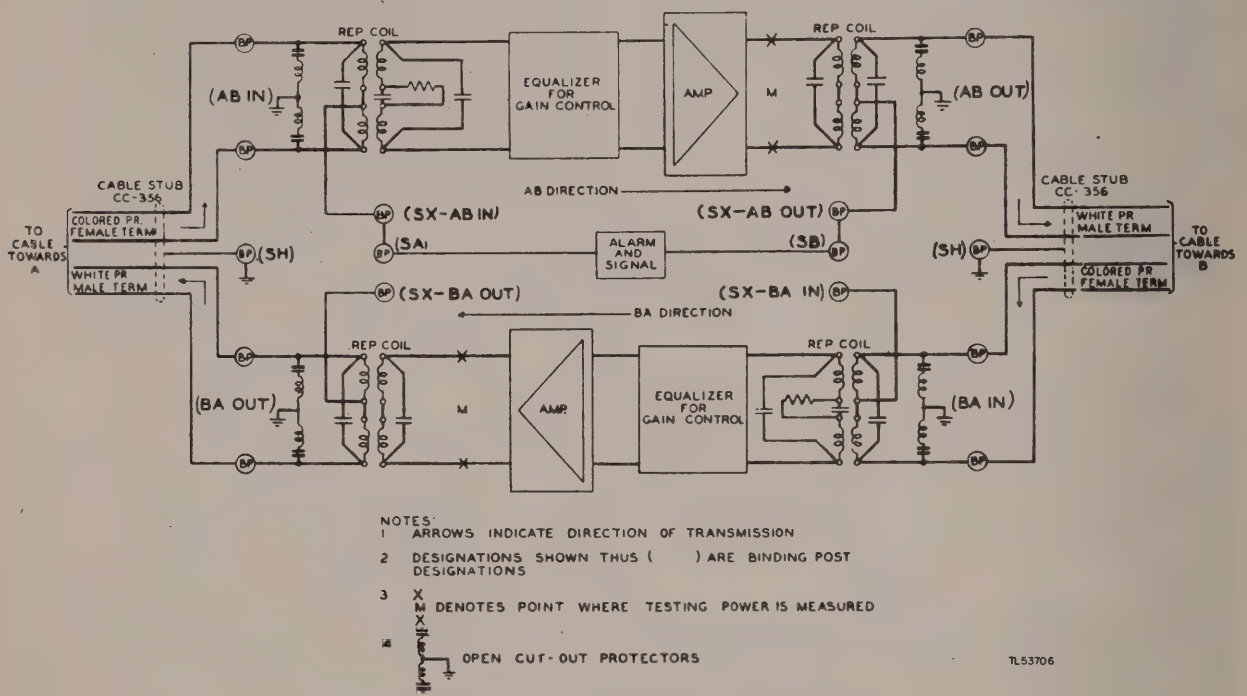


Figure 32. Repeater CF–3–A, block schematic diagram.

6-volt storage batteries at each terminal. When the system is operating on storage batteries, the drain will be about 3.75 amperes for each power supply panel. Power cords extend from the bottom of the bay for connection to the power supply and the emergency storage battery supply.

l. A system diagram (fig. 79) and schematic circuit label (figs. 81, 85, or 89) are mounted inside the front cover of the terminal, and a wiring circuit label (figs. 83 and 84, 87 and 88, or 90 and 91) is mounted inside the rear cover.

34. Electrical Characteristics of Repeater CF–3–A

a. Figure 32 is a schematic diagram of an intermediate repeater. The repeater is composed of two independent amplifying circuits, one of which

c. The power supply requirements are the same as those for the terminal with the exception that only one power supply panel is provided. The power required when operating on alternating current is 30 watts, and the d-c drain when operating from 12-volt battery is about 3.75 amperes.

35. Differences in Telephone Terminals CF–1–A and CF–1–B

a. The four channels of Telephone Terminal CF–1–B are arranged to be terminated on either a two-wire basis in which transmission in both directions is over the same pair of wires, or a four-wire basis in which transmission in each channel is over a different pair of wires. The four channels of Telephone Terminal CF–1–A are arranged for termination on a two-wire basis unless certain

changes described in paragraph 68 are made to Telephone Terminal CF–1–A. The change from two-wire to four-wire transmission with Telephone Terminal CF–1–B is made by a key associated with each channel circuit. Other minor changes have been made in the circuits of the four channels in Telephone Terminal CF–1–B.

b. The net loss of each channel on Telephone Terminal CF–1–B is measured at the output of the channel amplifier rather than at the two-wire side of the hybrid coil. A minor change in the transmission measuring circuit permits the same line-up procedure used with Telephone Terminal CF–1–A when channels are terminated on a two-wire basis.

c. A built-in talking and monitoring circuit is included in Telephone Terminal CF–1–B so that no Telephone EE–8–(*) is required for the attendant as is necessary when Telephone Terminal CF–1–A is used.

d. The differences in *a* to *c* above, have resulted in somewhat different installation procedures, and in different trouble-location tables.

e. The line coil and binding post panel of Telephone Terminal CF–1–B has binding posts which do not appear on the corresponding panel of Telephone Terminal CF–1–A. These are to accomodate the four-wire terminations and the two pads. Binding posts designated 4DB PAD No. 1 and 4DB PAD No. 2 have also been added to provide the required input or to lower the input between the terminal and the connecting equipment when a channel is terminated on a four-wire basis.

f. Two groups of keys are mounted on the talk and signal panel of Telephone Terminal CF–1–B while there is a single group on the corresponding panel of Telephone Terminal CF–1–A. The group common to both terminals is that which controls the alarm and signaling circuit. The second group on the panel of Telephone Terminal CF–1–B is for providing two-wire or four-wire terminations for each of the four channels. With the channel keys in the 2 WIRE positions the receiving circuit is connected to hybrid coil H, passes through the hybrid coil, and is terminated at the CHANNELS-2W or 4W TRANSMITTING binding posts T and R. In the 4 WIRE positions the receiving circuit is disconnected from hybrid coil H, a 300-ohm resistor N1 is placed across the hybrid coil, and is terminated at the CHANNELS-4W RECEIVING binding posts T and R.

g. The talking and monitoring circuit in Telephone Terminal CF–1–B is arranged to be used on channels terminated on either a two-wire or four-wire basis.

h. The handset provided with Telephone Terminal CF–1–B is equipped with a push-to-talk key. The receiver circuit of the handset terminates in a repeating coil R while the handset transmitter terminates in induction coil T. The other sides of these coils are connected to the TEL key.

i. There are minor differences in the transmission and measuring circuits of Telephone Terminal CF–1–B as compared with Telephone Terminal CF–1–A, but the circuits function in much the same manner and procedures for initial line-up of the equipment are alike. The measuring panel of Telephone Terminal CF–1–B is the same as that of Telephone Terminal CF–1–A except that the designation 2W on one of the six-position switch positions is changed to NET LOSS on Telephone Terminal CF–1–B.

36. Differences in Models of Telephone Terminal CF–1–A

a. The 16-db pad between the transmitting band filters and the transmitting amplifier which was used in models of Telephone Terminal CF–1–A with serial numbers 516 and lower is replaced in models with serial numbers greater than 516 by a 6-, 11-, and 16-db pad controlled by an OUTPUT key located on the panel marked CHAN 1. This permits outputs of either 0, +5, or +10 dbm to be transmitted from the terminal. Corresponding changes also are made in the models with serial numbers of 516 and higher to introduce pads in the measuring circuit under the control of the OUTPUT key for measuring the higher outputs.

b. The band filters used in the channel 3 and channel 4 panels are changed to permit the use of dielectric paper instead of mica capacitors in models with serial numbers of 516 and higher. The new filters, in general, have slightly more loss, and the pads associated with the filters are changed so that the combined loss of the filter and battery remains the same as in the earlier models. The difference in loss varies from 0.5 to 2 db.

c. The buzzer in the signaling and alarm circuit is replaced by a bell to obtain a more audible calling-in signal. The designation BUZZER

CUTOFF which appeared on models with serial numbers lower than 516 has been changed to SIGNAL CUTOFF on models with serial numbers of 516 and higher.

d. In models of Telephone Terminal CF–1–A with serial numbers 380 and higher, power supply panels are changed to include a 60-volt tap for operating the bell, a 10-ampere fuse in both leads to the 12-volt battery, and an improved circuit for effecting the transfer from alternating current to battery operation. The circuit in models with serial number 380 and lower requires closer regulation of the a-c frequency. Terminals with serial numbers greater than 380 have a new circuit label inside the front cover.

e. Six multiple outlets and a single 8-foot cord for connection to the a-c supply are provided in the base of the bays in models with serial numbers of 516 and higher. In these models also the cords of the power supply panels have been shortened and connection is made to the outlets of the bay. The additional outlets may be used for the ringing equipment or other equipment associated with the system.

37. Differences in Models of Repeater CF–3–A

Minor additions and changes have been incorporated in later models of Repeater CF–3–A. These differences are as follows:

a. In repeaters with serial numbers beginning with 1100, key-controlled pads of 5 and 10 db have been added in the measuring equipment to permit measuring outputs of 0, +5, and +10 dbm.

b. In repeaters with serial numbers of 1100 and greater, a bell replaces the buzzer in the alarm and signaling circuit to provide a more audible calling-in signal. The designation BUZZER CUTOFF has been changed to SIGNAL CUTOFF.

c. The power supply panels in repeaters with serial numbers greater than 723 are changed to include a 60-volt tap for ringing the bell, a 10-ampere fuse in both leads to the 12-volt battery, and an improved circuit for effecting the transfer from alternating current to battery operation. These changes have been shown on the circuit label inside the front cover.

d. Two multiple outlets have been added in the base of the bay in models with serial numbers 723 and higher, and a single 8-foot cord is provided for making connection to the a-c supply. One outlet is used for connection to the power supply circuit and the second outlet is available for miscellaneous use.

Section II. APPLICATION

38. System Application

Figure 2 is a general schematic diagram of a system comprising two terminals and one intermediate repeater. The four telephone circuits which the system provides are accessible for connection to switchboards, telephones, carrier telegraph equipment, etc. The system can be operated on spiral-four cable, as shown in figure 2, or it may be operated on Wire W–143, open wire, a Carrier Hybrid CF–7 system, pair-per-system, open-wire converter system, or with a radio relay.

39. Spiral-four Carrier System

a. In this system transmission from terminal A to terminal B is over one pair and transmission from B to A is over a second pair. Spiral-four cable is described in detail in TM 11–369. Paragraphs 64 and 67 describe types of spiral-four cable used in making connections in a system of this type.

b. The spiral-four cable may be buried, laid on the ground, or suspended from poles. When buried, variations in loss of the cable with temperature changes are materially reduced because the temperature range will be much less. This is especially important where wide variations in temperature occur daily. Figure 96 shows the approximate attenuation per mile at various temperatures of a line composed of Cable Assemblies CC–358. Temperature-resistance characteristics of spiral-four cable are shown in table LIII.

c. Normal repeater spacings are about 25 miles; these are limited by noise and available repeater gain. When noise is low, somewhat longer spacings can be used with special line-up methods. When intermediate repeaters are not used, as in figure 34, circuit lengths up to 45 miles or more may be used by increasing the transmitting output level at the terminal. Sufficient gain is available to permit nonrepeatered systems as long as 70 miles with 30-db net loss under very favorable noise conditions. The d-c telegraph circuits are provided over the two simplexes on the cable, one of these normally being used as a signaling channel. The other is used for short distances for telegraph purposes.

40. Wire W–143

a. The spiral-four system can be used over two pairs of nonloaded Wire W–143 with repeater sections about 14 miles long. A special equalizer is required if one or more intermediate repeaters are involved. This equalizer consists of an 11-

millihenry inductance in series with an 80-ohm resistor shunted across the input of each repeater and terminal.

b. The equalizer shown in schematic form in figure 35 can be made up in the field by using two Coils C–114 or C–114–A and connecting the windings of each coil in parallel aiding. Then connect the two coils in parallel and in series with 80 ohms resistance. Each winding of Coil C–114 or C–114–A has 44-millihenry inductance. The two windings of each coil in parallel aiding have about 22-millihenry inductance. Therefore, the two coils in parallel with their windings in parallel have about 11-millihenry inductance.

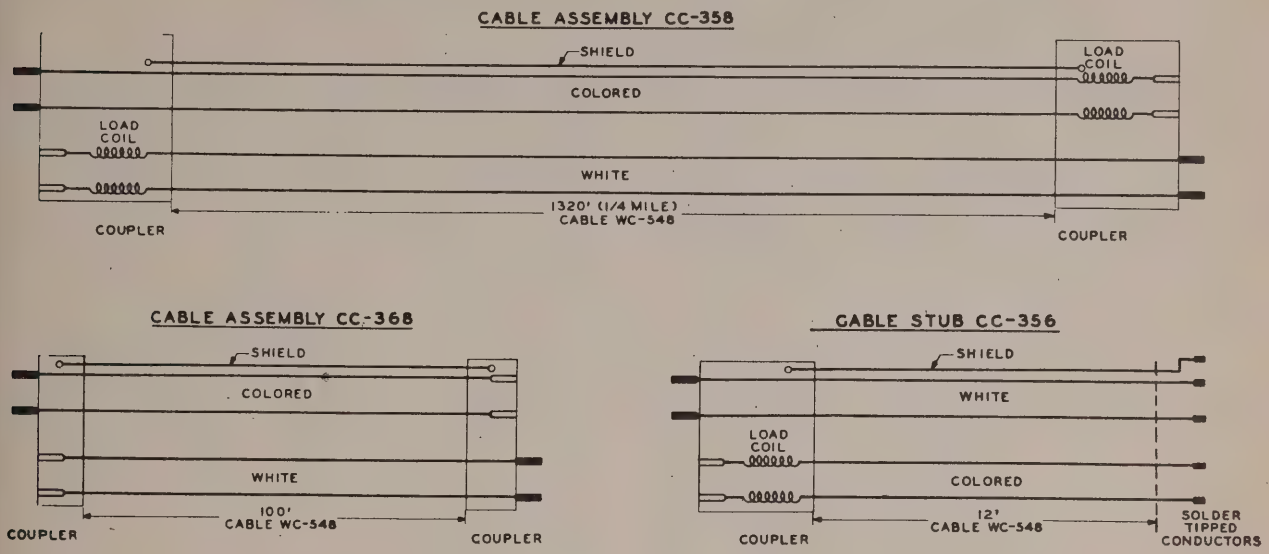


Figure 33. Spiral-four Cable Assemblies CC–358 and CC–368 and Cable Stud CC–356, schematic diagram.

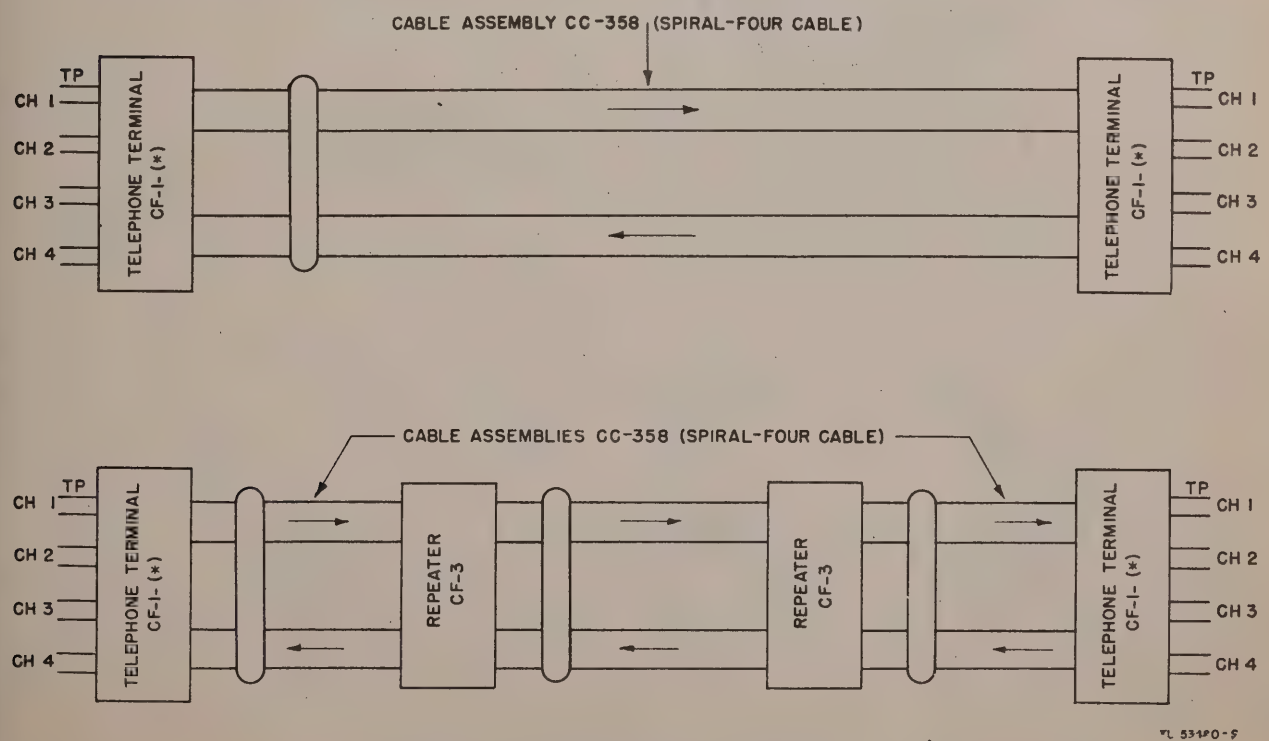


Figure 34. Spiral-four cable carrier system.

41. Emergency Operation Over Wire W–143 Without an Equalizer

It may be desirable to operate temporarily over nonloaded Wire W–143 under certain conditions when an equalizer is not available. The amount of distortion in the loss-frequency characteristic of channel 1 is severe when an equalizer is not provided. Because of this, no more than one repeater should be operated in this way. Without repeaters, it may be possible to operate over the full 17 miles for 6-db net loss circuits, and over not more than 28 miles for the 30-db net loss circuits. In many of these cases, however, the loss-frequency characteristic of channel 1 will have a large slope, and it may be necessary to operate channel 1 at greater net loss to prevent the circuit from sounding hollow or singing.

42. Open Wire

a. The spiral-four system can be used as a physical four-wire system on two open-wire pairs. This system is set up in the same way as the spiral-four cable system, except that simplified instructions with the equipment do not give typical equalizer setting for open-wire circuits. These settings can be determined during the line-up tests except for the MILES dial of the equalizer which should be set on step 0 for copper wire and step 30 for copper-steel wire. The lines may be

Table I.—Carrier operation over nonloaded wire W–143.

	Length in miles †				
	6-db net loss circuits*				30-db net loss circuits, no repeater
	No repeater	One repeater	Four repeaters	Eight repeaters	
Maximum repeater sections	17	15	14	13	28
Total length of systems	17	30	70	117	28

*When more than three repeater sections are used it may be necessary to bury all the cable so that variations caused by weather changes do not become excessive.

†The lengths shown are for maximum repeater sections. In general, system line-up and maintenance will be simplified if section lengths about 2 miles shorter than those listed are used when possible. When the line wire is not in good condition, still shorter sections will be desirable.

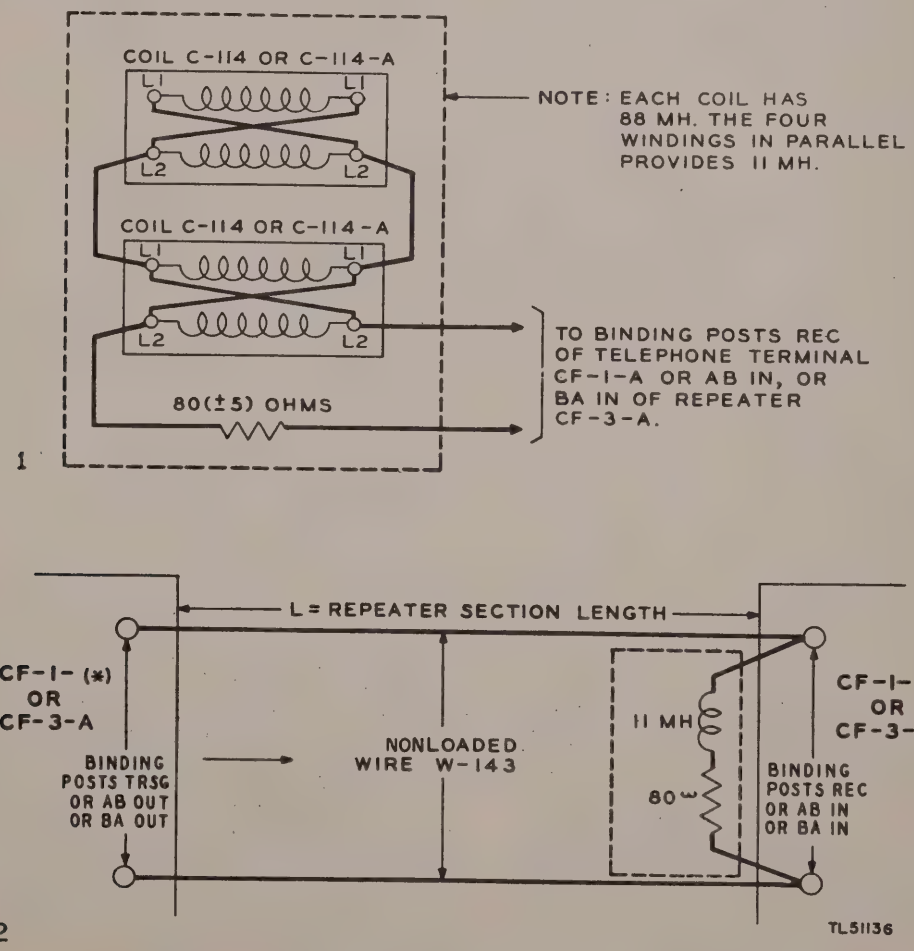


Figure 35. Arrangement for equalizing nonloaded Wire W–143.

terminations of open wire, Cable Assembly CC–358, or Wire W–143 without serious effects on transmission except from increased loss. This makes the system useful in front areas where well constructed open-wire lines may not exist. Single systems may be operated on a nonrepeatered basis for lengths of 100 miles or more of open wire, giving four circuits on two pairs of wires. Circuit lengths can be increased by the use of repeaters. Two systems on the same line lead to crosstalk difficulties and require much shorter section lengths and repeater spacings for high grade crosstalk performance.

b. This system cannot be used without high cross talk on open-wire leads carrying the open-wire Converter CF–4, Carrier Terminals OA–11/FC, OA–12/FC, and OA–13/FC, or other four-wire systems.

43. Carrier Hybrid System

a. Carrier Hybrid CF–7, in combination with spiral-four equipment, is used for balanced two-wire carrier operation over open-wire lines. This saves one pair as compared with the operation described in paragraph 42, but places restrictions on the length of repeater sections and the required regularity of line construction. Figure 36 is a schematic diagram of a balanced two-wire carrier hybrid system. TM 11–2003 describes Carrier Hybrid CF–7 in detail.

b. Repeater section lengths must be kept short in this system to avoid singing difficulties. On well constructed lines with small irregularities, nonrepeatered circuits can be worked for 65 miles at 6-db net loss and 135 miles at 30-db net loss on 0.080 copper-steel pairs. Longer lengths can be operated with repeater spacings of about 50 miles on this wire. If the lines are damaged or poorly constructed and have changes in wire spacing or gauge, or have short lengths of inserted cable, usable gains will be decreased. Such irregularities may reduce the maximum lengths of nonrepeatered circuits to not more than 45 miles at 6-db net loss and 115 miles at 30-db net loss. This characteristic of the carrier hybrid system should be considered in laying out systems in front areas because irregularities in line construction are likely to be more common there.

c. Operation of more than one carrier hybrid system on a line is limited by near-end crosstalk between oppositely directed paths. The limitations are not as severe as in the use of spiral-four equipment on the physical four-wire basis because lower gains are used and greater separation can generally be attained between different systems. On new carrier transposed lines in army construction, it will be generally possible to operate two carrier hybrid systems on the outside pairs of a crossarm without high crosstalk. Existing lines may have poor crosstalk characteristics and operation of more than one system will generally involve accepting higher crosstalk, increased circuit net losses, or reduced repeater spacings.

d. The carrier hybrid system can be used on Wire W–143 or Cable Assembly CC–358 for moderate distances. If both pairs of the spiral-four are used for these distances, crosstalk between the two systems will exceed the maximum tolerable for forward areas. If one pair of Cable Assembly CC–358 becomes damaged in the spiral-four system, operation on a balanced two-wire basis in the faulty section can be used as an emergency method.

e. The carrier hybrid system can be converted easily to a physical four-wire system, or vice versa, especially in the case of nonrepeatered systems. This allows considerable flexibility in the use of the two systems. Where sufficient pairs are available, physical four-wire operation provides a more stable and less vulnerable system with wide latitude in make-up of the line wires. The carrier hybrid system is for use where pairs are at a premium and the distance to be spanned is within the capabilities of the system as limited by line irregularities. Use of the system on very irregular lines and front areas is possible on a single-section

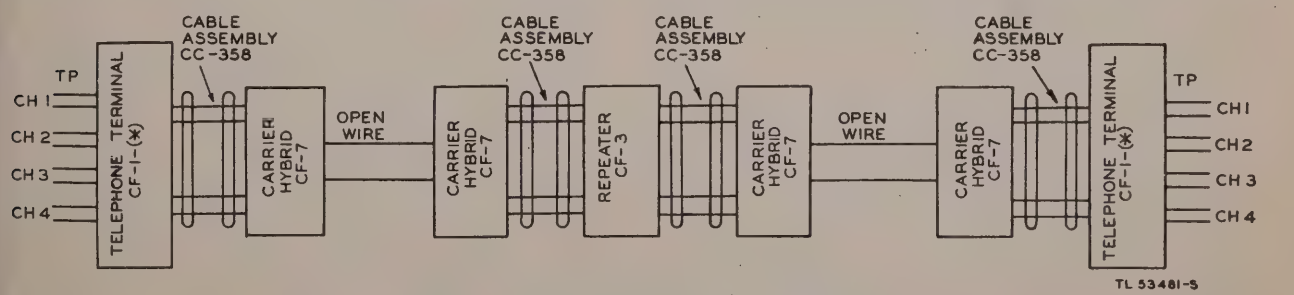


Figure 36. Balanced two-wire carrier hybrid system.

basis provided no attempt is made to insert large amounts of gain. That is, the system may be used to yield more circuits on a pair of wires but not to increase the range any great amount in such cases.

f. Directions for separating the carrier terminal and its associated hybrid and for making connections between the two made on a four-wire basis are given in paragraph 69.

44. Pair-per-System Operation

a. Pair-per-system operation is an emergency method for operating over open-wire line and it is illustrated in figure 37. This is a stop-gap arrangement for use only when Carrier Hybrids CF–7 are not available and there are not sufficient pairs to allow physical four-wire operation.

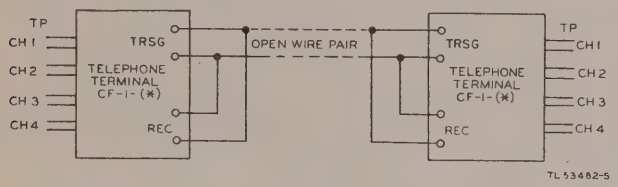


Figure 37. Pair-per-system carrier operation.

b. It is not possible in this system to insert gain at either terminal as this would cause circuit instability and singing. For satisfactory operation, the dial settings should be approximately as indicated in paragraph 52*d*. With these settings the over-all net loss of each channel will exceed the line attenuation by about 9 db. The circuits will be stable under all conditions.

c. The circuit links are limited to about 25 miles on 0.080 copper-steel wire for circuits having 18-db net loss, and about 60 miles for point-to-point circuits with 30-db net loss. Distances about three times as long can be spanned on 0.104 copper wire. Any inserted cable would reduce these links by the insertion loss of the cable.

d. Paragraph 71 gives detailed instructions for the procedure for setting up this system.

45. Operation Over a Single Pair of Spiral-four Cable Without Carrier Hybrids CF–7 or Converter CF–4

a. If Carrier Hybrids CF–7 or Converters CF–4 are not available, it is possible to have temporary operation over a repeater section using a single pair of spiral-four cable. In this case it will be necessary to operate the channels at increased circuit net loss. The minimum net losses that are possible are dependent upon the length of the damaged cable section. For a length of 25 miles, the net losses will be about 28 to 33 db. Greater lengths may result in failure to ring over the telephone channels and in unsatisfactory operation of the carrier telegraph system. The d-c simplex circuit of the good pair may be used for the signaling circuit or for telegraph.

b. Use the following procedure for operating over a single pair of the cable between terminals of *nonrepeatered* systems:

(1) At each terminal, throw the OUTPUT key lever, if one is provided, to the +10 position and set the equalizer dials as follows:

MILES	1	4	2	GAIN
Cable distance to adjacent station	0	0	4	21

If either or both terminals are not equipped with OUTPUT keys, both terminals should send at 0 dbm and increase dial 1 10 db.

(2) At each terminal, disconnect the bad pair from the binding posts and connect the good pair to the TRSG binding posts, connecting from the TRSG–T to the REC–T binding posts and from the TRSG–R to the REC–R binding posts.

(3) At terminal A, send 1,000-cycle test power on channel 1 by throwing the SEND key, and read the received channel 1 output at terminal A by throwing the MEAS key. Adjust the equalizer dial 1 until −5 dbm is read on the upper scale of the meter. Repeat this procedure on channel 4, adjusting equalizer dial 4 until a meter reading of −5 dbm is obtained. The dial settings should not be changed.

(4) Repeat the procedure given in (3) above, at terminal B.

(5) Throw the switch on the ringing equipment associated with the telephone channels to the HIGH RANGE position. Talk over each of the four channels. If a channel talks hollow or sings, decrease the CHANNEL GAIN dial until the channel talks satisfactorily. Check ringing over each channel. If the cable section exceeds about 25 miles, there may be some difficulty in signaling over the channels.

c. Use the following procedure when a *repeater* section in a *repeatered* system is to be operated over a single pair of the cable:

(1) Disconnect the bad pair and connect the good pair to the AB OUT or BA OUT binding posts. Strap the AB OUT to the BA IN binding posts, or the BA OUT to the AB IN binding posts, depending upon which side of the repeater faces the bad cable section.

(2) At a repeater or repeaters adjacent to the damaged cable section, set the equalizer dials as follows:

Repeater direction	Dials			
	MILES	1	4	2
Receiving from damaged cable.	For cable distance to adjacent station.	0	0	4
Receiving from good cable.	Set at normal operating settings.			

(3) At both terminals, even though they are not adjacent to the damaged cable, throw the OUTPUT key levers to +10. If either or both terminals are not equipped with OUTPUT keys, both should send at 0 dbm, and dial 1 at repeaters and terminals receiving from the damaged cable should be increased 10 db.

(4) If one end of the damaaged cable section is adjacent to a terminal proceed as in *b* above, for that terminal.

(5) All other repeaters and terminals on the system should operate with normal dial settings. It usually will not be possible to measure outputs at repeaters or at the receiving terminal beyond a damaged cable section.

(6) At both terminals, throw the switch on the ringers associated with the telephone channels to the HIGH RANGE position. For damaged cable sections longer than about 25 miles, there may be some difficulty in ringing over the circuits.

d. If an OUTPUT key is not provided, the output of the system will be 10 db lower than it is when the system is operating as described in *b* and *c* above, and the channels of the system may have more noise. If an OUTPUT key is provided and the +10DB position does not permit the equalizer dial 1 to be adjusted to obtain the —5-dbm reading on the meter, throw the key lever to the +5DB position at both terminals and adjust dial 1 to obtain the —5-dbm reading.

e. Monitor all channels occasionally to be sure singing does not occur. If necessary, reduce the GAIN dial on the channel that is singing until no singing or hollow sounds is present.

f. If temporary use of a single pair of the cable is made in this manner and the condition lasts more than 1 day, check the system each day.

46. Open-Wire Converter System

a. The open-wire converter system is an equivalent four-wire system designed for operation over open-wire pairs without the limitations of balance and near-end crosstalk involved in the use of physical four-wire and carrier hybrid systems. This system uses Telephone Terminal CF–1–(*) (Carrier), Converter CF–4 (Carrier, 2-wire—4-wire), and Repeater CF–5 (Carrier, 2-wire).

b. Figure 38 shows a schematic lay-out of a repeatered open-wire converter carrier system.

c. The system will provide four circuits having 6-db net loss for distances up to 400 to 800 miles. The normal repeater spacing on 0.080 copper-steel wire is 80 to 90 miles. Noise and available gain limit the length of the repeater spacings. When used as a single-section system without repeaters distances up to 135 miles and 200 miles can be spanned on 0.080 copper-steel wire for circuit net losses of 6 db and 30 db, respectively.

d. On open-wire lines transposed as outlined in TM 11–368, each pair may be used for an open-wire converter system. The system may also be used on the same pole line with army fixed plant carrier systems and most foreign systems.

e. Combinations of open-wire converter system on open wire in tandem with a spiral-four system on Cable Assembly CC–358 can be operated without bringing the channels down to voice frequencies at the junction point. Converter CF–4 and Repeater CF–3–A are used at the junctions in these cases.

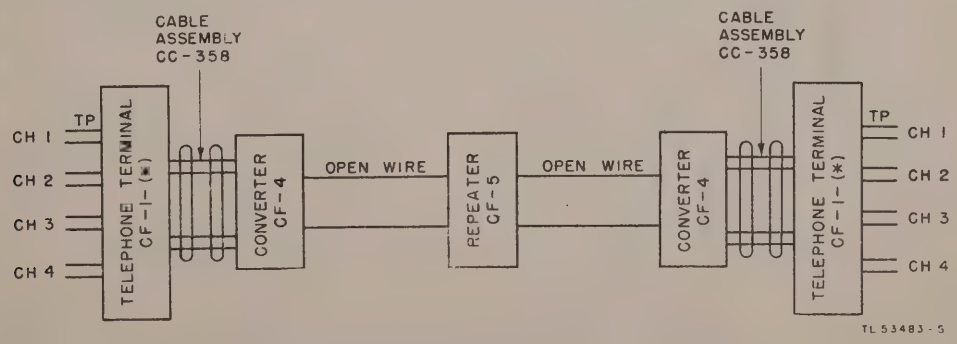


Figure 38. Open-wire converter carrier system.

f. Directions for setting up this type of system are given in paragraph 72.

47. Radio Relay

a. Radio systems may form links in a wire circuit with carrier frequencies passing over the wire and radio in combination. A four-channel radio system designed to be used in this manner is available. Figure 39 shows such a system using carrier telephone and telegraph equipment and Radio Terminal Set AN/TRC–3.

b. The distance over which Radio Terminal Set AN/TRC–3 and Radio Relay Set AN/TRC–4 will operate satisfactorily depends primarily upon the character of the terrain between the radio transmitters and receivers and the choice of the antenna locations. The distances over which satisfactory operation maybe expected vary from a few miles to more than 50 miles. TM 11–2601 discusses the performance of these radio sets. It is assumed for one of the links (between two radio relay sets) that the situation often requires that amplifier equipment be used to increase transmitted power.

c. This radio system transmits frequencies from about 200 to 12,000 cycles which is the frequency band required by the telephone carrier system. Thus, used in combination with spiral-four carrier terminal equipment, it will provide four telephone circuits, any one of which can be used to provide four voice-frequency telegraph circuits.

d. The radio system may form merely a link in a carrier system to span some difficult terrain such as a water crossing, in which case the carrier terminal equipment should be at the terminals of the wire system.

48. Four-Wire Operation of Telephone Terminal CF–1–A

a. A channel of Telephone Terminal CF–1–A can be arranged in the field for four-wire operation and voice frequencies. Such arrangements may be made to obtain improved telephone operation under certain conditions, or to increase the number of voice-frequency telegraph channels operated over a telephone channel of the carrier system when the type of telegraph operation makes this desirable.

b. Figure 53 shows Telephone Terminal CF–1–A arranged for four-wire operation, and paragraph 68 describes procedure for arranging Telephone Terminal CF–1–A for such operation.

49. Dropping Channels at Intermediate Points

a. When it is desired to drop or bridge onto one or more of the four channels of the carrier system at some intermediate point, it generally will be necessary to provide two Telephone Terminals

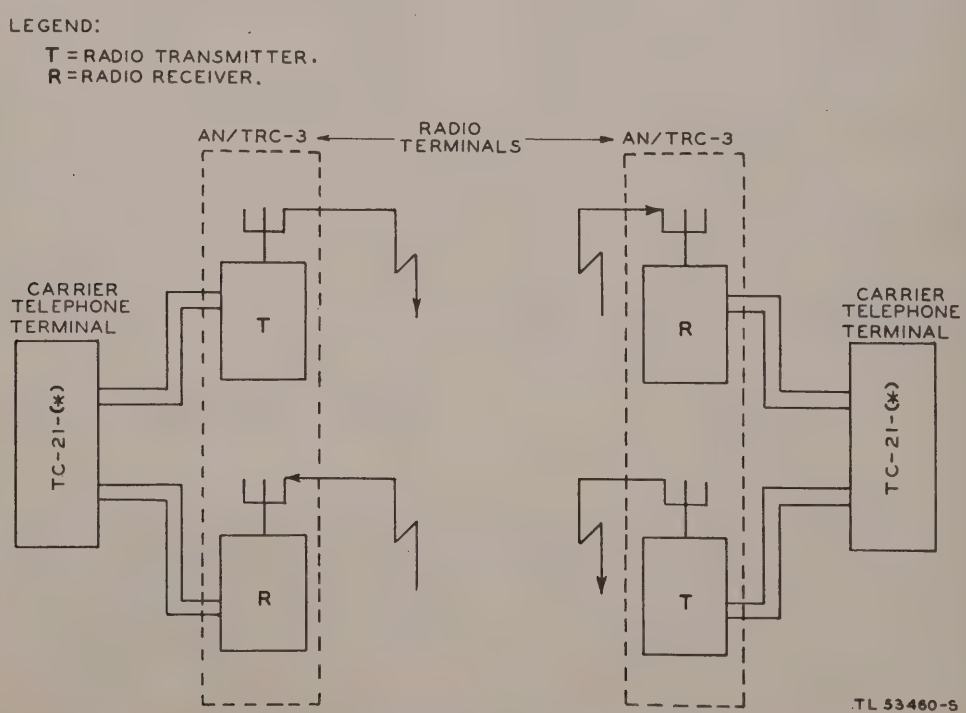


Figure 39. Four-channel radio relay carrier system.

CF–1–A or CF–1–B at the dropping or bridging point.

b. The two terminals are operated "back to back," and any of the channels may then be brought out and dropped, bridged onto, or carried through by interconnections between the channel binding posts. In this way the single system becomes two systems working in tandem, and the channel carried through, with or without bridged extensions, requires special line-up to obtain proper over-all channel losses. A recommended procedure for dropping channels at intermediate points is outlined in paragraph 75.

c. With this arrangement the channels brought out and dropped will have the normal channel loss of 6 db. The channels carried through two systems without bridged circuits ordinarily would have a total loss of 12 db since there would be two 6-db channels in tandem. The special line-up procedure provides for reducing this over-all loss to the normal channel loss of 6 db. Channels carried through two systems with a bridge circuit would ordinarily have an over-all loss of 15 db from end to end, and a loss of 9 db from the bridge to either end. The losses in the extension facilities connected to both ends of the channel being considered must be added to the above losses to obtain the loss of the over-all circuit.

d. Telegraph terminals are not required if no telegraph channels are to be dropped off or carried through an intermediate teletypewriter set at the dropping point. In this case the carrier telephone channel used for telegraph is carried through by interconnection between the channel binding posts or the two telephone terminals. Telegraph terminals are required if one or more telegraph channels are to be dropped off or carried through an intermediate station.

50. Extension Circuits at Repeaters

a. General. (1) By the use of readily available equipment, short extension circuits can be bridged onto channel 1 at Repeaters CF–3–A without extensive modification of the repeaters. Such circuits can be used to provide limited telephone communication with either of the carrier system terminals, with other repeaters on the carrier system, or with extensions from these terminals or repeaters.

(2) Over such circuits the loss in transmission from a terminal to an extension located at a repeater is about 24 db, and the loss in the opposite direction is about 10 db. To keep the loss between telephones less than 30 db (about the maximum allowable), the total of the lengths of the extension facilities at both ends of the circuit must not introduce more than about 6-db loss (a total of about 3 miles of Wire W–110–B) for circuits from repeater locations to terminal locations, or more than about 2-db net loss (about one mile of Wire W–110–B) for circuits between repeater locations. When an extension is located at a repeater and both Telephones EE–8–(*) are not required, about 3 db may be subtracted from the above loss.

(3) As described in *b* below, it will be necessary to make special provision and prescribe special procedures for ringing or signaling to and from telephones on the bridged extensions. Figure 54 shows connections for a bridged extension telephone at a repeater.

b. Operation With Extension Circuits at Repeaters. (1) The field telephone at the repeater is used in place of the repeater handset for all normal system maintenance. The signaling circuit is used in the usual manner.

(2) If voice-frequency ringing equipment is used on the extension, the TEL key on the repeater can be left in the A or B position, depending whether normal communication from the extension is to be in the direction of terminal A or terminal B. A system of code ringing with the hand generator should be prescribed for calling the extension or repeater station from other points on the circuit.

(3) If no voice-frequency ringing equipment is available it will be necessary to call the repeater operator first on calls from the extension, using the hand generator. Then have the repeater operator relay the call over the signal circuit to the desired distant repeater or terminal, and have the operator at the distant repeater or terminal relay the call to the desired station or switchboard. The reverse operation is used when calling the extension station. The entire procedure is awkward and should be avoided if possible because all calls to or from the extension require the operation of the signal bells at all repeaters and both terminals whether or not there are extensions at those points. If a 1,000/20-cycle whistle is available at the extension station, calls can be made from it to telephones or switchboards connected to channel 1 at either terminal of the carrier system. However, an extension from a repeater must be called over the signaling circuit if there is no voice-frequency ringing equipment installed on the extension.

(4) If it is desired to change the direction in which the extension station is to communicate,

that is, towards terminal B instead of towards terminal A, it is necessary to call the repeater operator from the extension station and request him to change the position of his TEL key from A to B.

(5) In all cases, it is essential to listen on the line before ringing or talking over it to be sure that it is not already in use.

51. System Lay-Out

The permissible distance between carrier repeaters and between terminals and repeaters is limited by the available gain and the amount of noise that is consistent with satisfactory transmission. The controlling source of noise probably will be atmospheric static. Experience will indicate the practicability of using longer carrier sections in some localities where static is extremely variable, higher during the summer months and reaching a peak during electrical storms. On the voice-frequency channel, noise due to power induction may be important and will depend on the power system characteristics and the separation between the power and the telephone lines.

52. Gain and Equalizing Arrangements

The gain and equalizing arrangements provided in the carrier terminal and repeater equipment are suitable for spanning 30-mile repeater sections with spiral-four cable under maximum temperature conditions. With spiral-four cable, the average spacing between carrier points should ordinarily be kept to about 25 miles with only an occasional 30-mile section. For systems using two or more intermediate repeaters it will be desirable to bury as much of the cable as practicable. Cable placed underground varies less in temperature than cable on the ground or in the air. Consequently, less frequent maintenance adjustments are required to compensate for the variations in cable loss due to temperature changes.

a. When the system is on Wire W–143 a special equalizer is required if one or more intermediate repeaters are involved. This equalizer consists of an 11-millihenry inductance in series with an 80-ohm resistor shunted across the input of each repeater and terminal. Satisfactory circuits can be obtained in this way for lengths up to about 100 miles.

b. Although the method for setting up the system on open wire is the same as for spiral-four cable, typical equalizer settings for open-wire circuits must be determined during the line-up tests except for the MILES dial of the equalizer which should be set on step 0 for copper wire and step 30 for copper-steel. Even though the lines used may be combinations of open wire, Cable Assembly CC–358, or Wire W–143, there will be no serious effects on transmission except some increased loss. Single systems of this type may be operated on a nonrepeatered basis for lengths of 100 miles or more of open wire, giving four circuits on two pairs of wires.

c. In Carrier Hybrid CF–7 systems, repeater section lengths must be kept short to avoid singing difficulties. When lines are well constructed and there are small irregularities, nonrepeatered circuits can be worked for 65 miles at 6–db net loss and 135 miles at 30–db net loss on 0.080 copper-steel pairs. On this type of wire longer lengths can be operated with repeater spacings of about 50 miles.

d. In the emergency method for operating over open-wire lines on a pair per system, it is not possible to insert gain at either terminal as this would cause circuit instability and singing. For satisfactory operation, the dial settings should be approximately as indicated in table II.

Table II

Dial and key settings at each terminal

MILES dial	Dial 1	Dial 4	Dial 2	GAIN dial	REC LEV key
0	*0	0	4	20 (channel 1 to 3) 22 (channel 4)	Normal.

*If OUTPUT key is not provided on terminal, set dial 1 on 10 instead of 0.

With these settings, the over-all net loss of each channel will exceed the line attenuation by about 9 db. The circuit will be stable under all line conditions. Circuit lengths under this system are limited to about 25 miles on 0.080 copper-steel wire for circuits having 18-db net loss, and about 60 miles for point-to-point circuits with 30-db net loss. Distances about three times as long can be spanned on 0.104 copper wire. Any inserted cable would reduce these lengths by the insertion loss of the cable.

e. On open-wire converter systems the normal repeater spacing on 0.080 copper-steel wire is 80 to 90 miles. Noise and available gain limit the repeater spacings. When used as a single-section system without repeaters, distances up to 135 and 200 miles can be spanned on this type of wire for circuit net losses of 6 and 30 db, respectively.

53. Noise

a. The amount of noise contributed by spiral-four cable depends upon whether the cable is buried, laid on the ground, or placed in the air. With good maintenance and repeater spacings of about 25 miles, the noise should ordinarily not be excessive for systems as long as 150 miles when the cable is not buried or for systems as long as about 400 miles when all the cable is buried. In areas where atmospheric static fields are high, however, there may be difficulty at times with the longer systems in obtaining a signal-to-noise ratio great enough to permit covering with ease. In these cases some improvement can be realized by using shorter repeater spacings. In general, the amount of noise is reduced about 1 db for each mile reduction in repeater spacing.

b. A system using open wire cannot be operated without high crosstalk on open-wire leads carrying the open-wire converter, Carrier Terminals OA–11/FC, OA–12/FC, and OA–13/FC, or other equivalent four-wire systems.

c. Operation of more than one carrier hybrid system on a line is limited by near-end crosstalk between oppositely directed paths. The carrier hybrid system can be used on Wire W–143 or Cable Assembly CC–358 for moderate distances, but if both pairs of the spiral-four cable are used for these distances crosstalk between the two systems will approach the maximum tolerable for forward areas.

54. Output

The normal output of the terminals and repeaters is 0 dbm. The system may be operated over a distance up to 45 miles without intermediate repeaters by increasing the output of the terminal to 10 dbm, as provided in the transmitting terminals. Additional gain is available at the receiving terminals which may be used to extend this length somewhat when noise conditions permit. The use of the higher output on repeater systems is not recommended except in emergencies since it will result in an increase in interference, which may be objectionable, between the several channels.

55. Net Loss

The net loss of individual channels of the carrier system may be adjusted to the desired value. Ordinarily a net loss of 6 db is desirable where the telephone circuits may be switched or operated with a permanent extension between the carrier terminal and the switchboard.

56. Maximum Gain

The maximum gain available in the common receiving circuit at a terminal or repeater is 24 db at 1,000 cycles and 30 db at 10,000 cycles and is adjustable in 1–db steps. A small amount of adjustment is provided for frequencies between 200 and 1,000 cycles and for frequencies between 1,000 and 10,800 cycles to care for the variations from a straight line characteristic. At terminals, an additional gain of 24 db is available in each channel amplifier over that required to attain a normal 6–db channel net loss. Another 10–db gain may be obtained by removing a 10–db key-controlled pad in the receiving circuit common to all four channels.

Section III. UNPACKING, SETTING UP, AND REPACKING INSTRUCTIONS

57. Location of Equipment

a. Place the carrier equipment in a sheltered location to assure protection against rain, snow, etc. Whenever possible, place the cases on a dry, secure footing such as dry boards, planks, etc.

b. Place the cases with the front cover facing out and the end marked TOP uppermost. When more than one terminal or repeater is to be located at the same point, the equipment, together with associated equipment, should be arranged in convenient alignment to prevent confusion in maintaining the carrier system.

c. Provide a platform or floor for the operators to stand upon when they work about the equipment.

d. If wood or other insulating material is not available, wire screening placed on the ground in front of the equipment and connected to the station grounding system will offer some protection from electric shock.

e. Provide adequate passage ways, working space, and convenient wiring for interconnecting lay-outs. Leave space enough in front of the equipment to permit convenient operation and, when possible, leave some space for access to the rear of the equipment.

f. If the equipment is to be used in an exposed location, replace the front cover of the terminals or repeaters after the equipment has been lined up and placed in service. When the cover is not replaced, store it near the equipment so that it will be convenient for reference to the system diagrams and the schematic diagrams located on the inside of the front cover.

g. Carry cable between the units and to the power equipment overhead when possible. Wiring

should be tied neatly, using the cable rings in the units wherever possible, and arranged so that it will not be damaged and will not be a hazard to traffic during normal operation.

h. Locate power units outside the building in which the terminals or repeaters are located, if such equipment is located in a building, so that the exhaust fumes will not be hazardous to operating personnel. Separate power wiring from transmission wiring between equipments. Locate Rectifier RA–83–A near the storage batteries for charging purposes.

58. Unpacking, Uncrating, and Checking

a. Tables III and IV give the weights and volumes of Telephone Terminal Set TC–21–(*) and Repeater Set TC–23–A crated for shipment. Some variation from these figures should be expected because of differences in the weights of shipping cases. Shipping tons for items similar to this equipment are usually calculated on the basis of 1 shipping ton per 40 cubic feet. The shipping weight of Telephone Terminal Set TC–21–(*) is approximately 2 shipping tons, and that of Repeater Set TC–23–A is approximately 1 shipping ton.

Note.—Telephone Terminal Sets TC–21–A (Carrier) and TC–21–B (Carrier) and Repeater Set TC–23–A (Carrier) are shipped from zone of the interior depots to oversea debarkation points as part of Carrier System AN/TCC–2, an assembly of standard tactical carrier apparatus, spiral-four cable, and line hardware normally required for the installation and operation of a multichannel communication system.

b. Each Telephone Terminal CF–1–(*) and Repeater CF–3–A is placed in a steel barrier and over-packed in a solid wood container. Accessory equipment and spare parts are packed in corrugated cartons wrapped in a waterproof liner, sealed, and over-packed in solid wood boxes. Be careful when unpacking or handling the carrier equipment as it can be damaged easily when it is not protected by the packing case. Do not apply pressure to meter faces. In unpacking, follow the steps outlined below:

(1) Place the packing cases as near the operating location as is convenient.

(2) Cut the steel straps around the packing cases.

(3) Remove the nails, using a nail puller, and remove the sides of the packing cases. The equipment may be damaged if attempts are made to pry off the sides of the cases.

(4) Remove the tops of the packing cases and the steel barriers or protective wrappings around the equipment.

Table III.—Weights and volumes of telephone terminal set TC–21–(*) crated for shipment

Package No.	Equipment	Quantity	Weight (pounds)	Volume (cubic feet)
1	Telephone Terminal CF–1–(*)	1	735	37
2	Battery BB–55	2	147	4
3	Includes the following:	-------	190	7
	Telephone EE–8–(*) (with Telephone Terminal Set TC–21–A only)	1		
	Tool Equipment TE–123	1		
	Test Equipment IE–53	1		
	Hydrometer HY–2	1		
	Cable Stub CC–356	2		
	Cord CO–38	2		
	Cord CD–711	2		
	Wire W–2	2 lb		
	Wire W–69–A	100 ft		
	Clamp TM–106	2		
	Ground rod clamp	2		
	Battery terminal (+)	2		
	Battery terminal (−)	2		
	Junction Box JB–110	1		
	Chest BC–5	1		
	TM 11–2001	1		
	TM 11–369	2		
4	Ground Rod MX–148/G	2	14	1
5	Power Unit PE–75–(*)	1	500	20
5	Power Unit PE–75–(*)	1	500	20
6	Case CS–111 (for Batteries BB–55)	1	50	2
7	Rectifier RA–83–A	1	76	3
8	Kit of running spares	1	10	1
	Total	-------	2, 222	95

Table IV.—Weights and volumes of repeater set TC–23–A crated for shipment

Package No.	Equipment	Quantity	Weight (pounds)	Volume (cubic feet)
1	Repeater CF–3–A	1	477	13
2	Battery BB–55	2	147	4
3	Includes the following:	-------	162	7
	Tool Equipment TE–123	1		
	Test Equipment IE–53	1		
	Hydrometer HY–2	1		
	Cable Stub CC–356	3		
	Cord CO–38	2		
	Cord CD–711	2		
	Wire W–2	2 lb		
	Clamp TM–106	2		
	Ground rod clamp	2		
	Battery terminal (+)	2		
	Battery terminal (−)	2		
	Junction Box JB–110	1		
	Chest BC–5	1		
	Kit of running spares	1		
	1-ampere fuse	7		
	Vacuum tube (6V6GT)	2		
	TM 11–2001	1		
	TM 11–369	1		
4	Ground Rod MX–148/G	2	14	1
5	Power Unit PE–214–(*)	1	110	5
6	Case CS–111 (for Batteries BB–55)	1	50	2
7	Rectifier RA–83–A	-------	76	3
	Total	-------	1, 036	35

Caution: When removing waterproofing and other protective coatings, be careful not to remove moistureproofing and fungiproofing coatings.

(5) Place the equipment near its final location.

(6) Remove Batteries BB–55 from the wooden case in which they are packed. Batteries are shipped dry. Electrolyte already mixed is shipped in 1-gallon bottles packed in sawdust in wooden cases. Fill Batteries BB–55 with electrolyte according to the directions on the top of the batteries, and place them in Case CS–111.

Note.—When uncrating the other components, take the same precautions as outlined in (1) to (6) above.

(7) Inspect the equipment visually for damage after removing it from the packing cases. Check the components against the master packing slip and the list of component parts in appendix I.

59. Assembly

a. Telephone Terminal CF–1–(*) and Repeater CF–3–A are shipped assembled. Vacuum tubes, power tubes, and necessary fuses are in their proper places. Spare vacuum tubes and fuses are mounted on the units, and a set of spare vacuum tubes and fuses are packed with each unit. The tubes are held in place with masking tape. Grasp the tube with one hand and remove the masking tape with the other hand. This method of handling eliminates the possibility of damaging the prongs of the tubes or the sockets.

b. Directions for assembling components of Telephone Terminal Set TC–21–(*) and Repeater Set TC–23–A which are shipped disassembled are provided in Technical Manuals applicable to and packed with those components.

60. Repacking

If the equipment is to be repacked for troop movement or is to remain out of service for some time, take the following steps:

a. Disconnect the a-c and 12-volt battery connections and coil the cords through the retaining rings. Tie the cords in place with the fabric tie-cords. Disconnect the cable studs and all wiring to the binding posts of the binding post panel.

b. Secure in place all spare parts, key guards, telephone handsets, and other loose parts.

c. Close the wiring outlets on the sides of the cases.

d. Place Technical Manuals in their holders.

e. Set the front and rear covers in place and fasten the trunk drawbolts securely.

f. Place the cases in a dry location.

g. Inspect the equipment at reasonable intervals to see that it is clean, free from rust, and has not been damaged. Clean and repair if necessary.

h. If the equipment is left in storage for more than 18 months the electrolytic filter capacitors of the power supply panels may lose their film. Directions for restoring this film are given in paragraph 179.

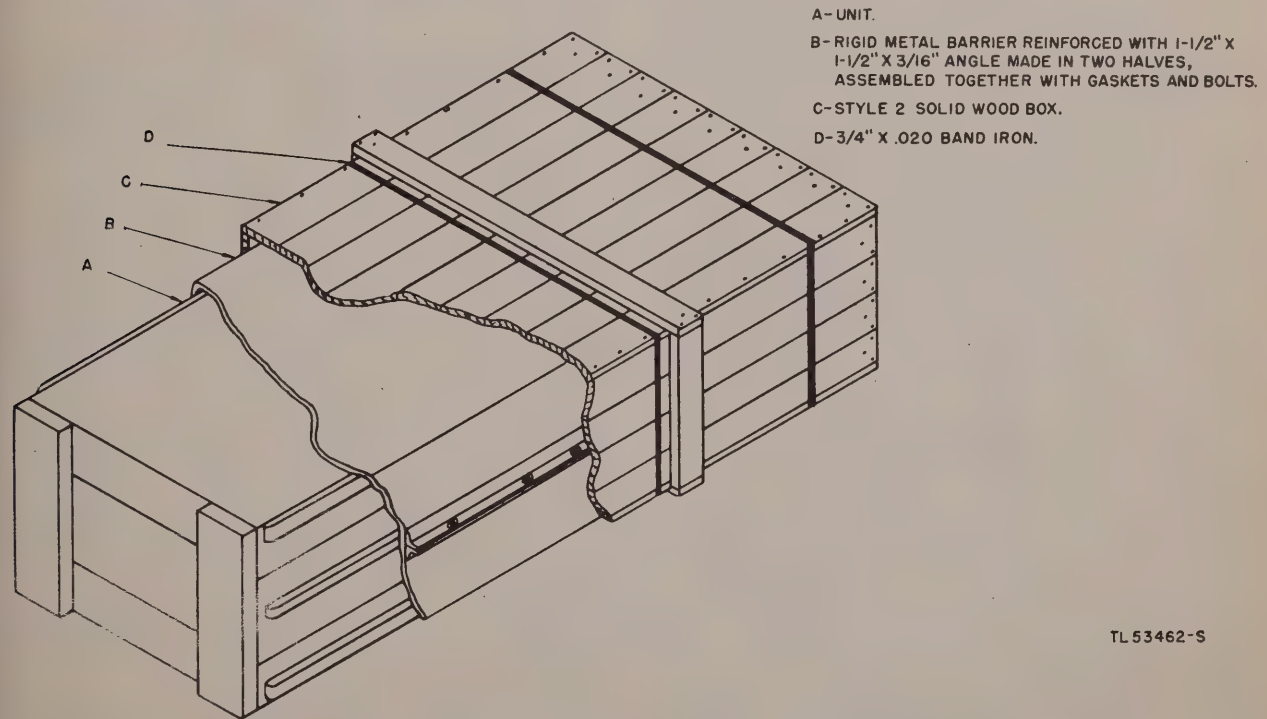


Figure 40. Method of packing Telephone Terminal CF–1–(*) and Repeater CF–3–A.

PART TWO

OPERATING INSTRUCTIONS

Note.—For information on destroying this equipment to prevent enemy use, see the destruction notice at the front of this manual.

Section IV. EQUIPMENT CONNECTIONS AND INITIAL ADJUSTMENTS

61. Power Supply Arrangements

a. GENERAL. The power supply panels used in Telephone Terminals CF–1–(*) and Repeaters CF–3–A are identical. Two power supply panels are provided with each telephone terminal and one with each repeater. Connections are required between a carrier terminal and the cable, between the carrier terminal and the associated equipment, to the a-c and d-c power supplies, and to ground.

Caution: Connections should not be made from the external a-c power source or 12-volt battery to the equipment until all of the power supply panel connections discussed in *b* below, have been checked.

b. POWER CONNECTIONS. (1) Before making connections to the external power supply the connections in the power supply panels must be arranged properly for operation on the voltage of the outside supply.

(2) Determine if the a-c supply is between 110 and 125 volts or between 220 and 250 volts and 50 to 60 cycles. Be sure the external a-c power cord and the connections to the 12-volt battery are not connected. Remove the covers from the front of the PWR SUP panels and make connections for the proper power voltage on the AC terminal strip according to the diagram on the inside of the PWR SUP panel cover. (See figs. 64 and 65.) These connections may be changed by using a screw driver. Table V lists the connections for different voltage supplies applying to models of Telephone Terminal CF–1–A with serial numbers below 380 and to models of Repeater CF–3–A with serial numbers below 723. Table VI gives the connections for different voltage supplies for the panels provided with models of Telephone Terminal CF–1–A with serial numbers 380 and higher, with Telephone Terminal CF–1–B, and with Repeater CF–3–A with serial numbers 723 and higher.

Table V.—Power supply panel connections for earlier models of terminals and repeaters

Lead	110–125 volts connect to terminal	220–250 volts connect to terminal
Blue	3	2
Red-white	1	2
Blue-red	4	3
Blue-white	1	1
Red	3	3

Table VI.—Power supply panel connections for later models of terminals and repeaters

Lead	110–125 volts connect to terminal	220–250 volts connect to terminal
Blue	3	2
Red-white	1	2
Yellow	5	4
Yellow-green	3	4

(3) Check that 1-ampere fuses are in the LAMPAC fuse mountings at the upper left-hand side of each PWR SUP panel and that spare 1-ampere fuses are provided in the 1-ampere SPARE mountings located inside of each cover.

(4) Check that 10-ampere fuses are in the 12 V BAT fuse mountings and that spare fuses are provided in the 10-ampere SPARE fuse mountings located inside of each cover. The 10-ampere fuses can be distinguished from the 1-ampere fuses by the values stamped on the fuses, and they are of different lengths.

(5) Replace the covers on each PWR SUP panel before making connections to alternating current or 12-volt batteries. The covers must be securely in place to hold the vibrators tightly in their sockets.

(6) Throw the SIGNAL CUTOFF key lever on the signal panel at the terminal and on the talk and signal panel at a repeater point.

(7) Connect the 12 V BAT cords with battery terminals to the 12-volt batteries. The 12-volt

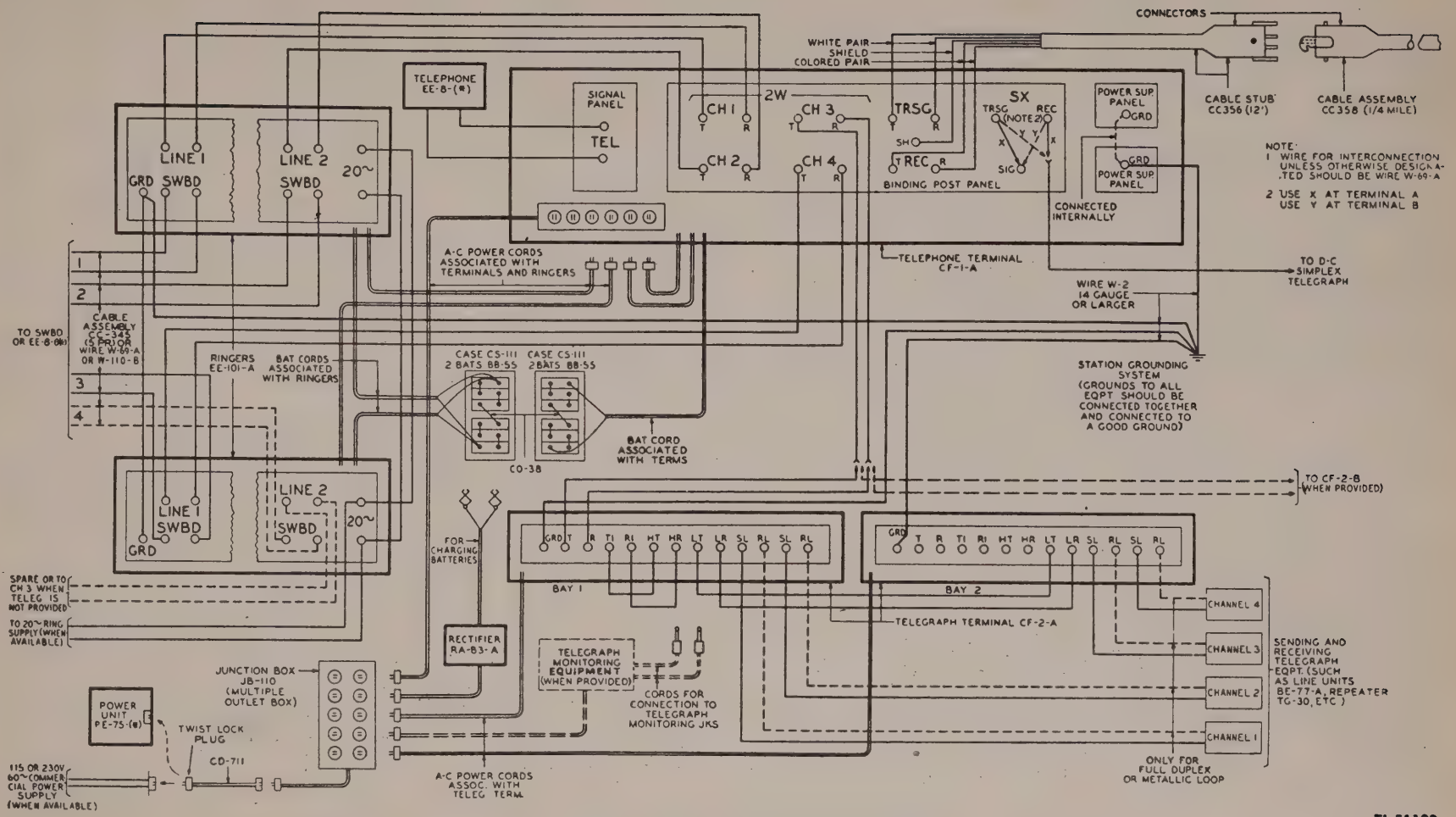


Figure 41. Carrier telephone terminal, cording diagram.

battery supply is made up of two 6-volt batteries connected in series. Make sure that the positive battery terminal of each battery is connected to the positive terminal of the cords marked 12 V+. The frequency generator on each power supply panel should hum. If the frequency generator does not start it may be necessary to tap it a few times. If it does not start, check that a properly charged 12-volt storage battery is used. Replace any vibrator that does not hum with the spare parts provided on the associated power panel.

(8) Plug both a-c cords into the outlets at the bottom of the bay. Plug the external a-c cord into any convenient a-c outlet. Early models did not have any outlets at the bottom of the bay. The frequency generator should cease to hum. If a portable source of a-c power supply is used, it may be necessary to adjust its output voltage and frequency. If it becomes necessary to remove the covers of the power supply panels, the connections to the 12-volt battery and the a-c cords should be disconnected before removing the covers. If it is necessary to have the covers removed and the power connected for testing purposes, great care should be taken.

Warning: *Hazardous voltages appear between certain apparatus terminals and between certain terminals and the framework (or ground) when the power is turned on. Avoid touching exposed terminals with the bare hands. Make all tests using suitably insulated test leads.*

62. Grounding Arrangements

a. A ground is required at each carrier terminal and repeater to minimize hazard to the equipment and to personnel from lightning and other sources of high voltage, to reduce noise pick-up and to supply the return circuit for the simplex facilities. It is important that all equipment at any one location be connected to the same grounding system. Detailed grounding instructions may be found in TM 11–755.

b. Where a buried water supply piping system is available the carrier equipment should be grounded to it. No. 14-gauge wire or larger should be used. A larger gauge wire may be required for mechanical strength.

c. Where such a ground is not available, connect the equipment to the best practical ground such as a local water system, buried gas pipes, underground tanks, or other metallic structures, or use driven rods as a common ground for the carrier equipment and the secondary power distribution circuit. The conductor from the carrier equipment to ground should be No. 14 gauge or larger. Precautions should be taken to protect the conductor from mechanical damage. The conductors for grounding other equipment at the same location should be connected to the common ground and not to the ground terminal or repeater equipment.

d. Where ground rods are used in areas of high resistance such as sandy or rocky ground, drive a number of rods not less than about 10 feet apart and connect them by No. 14-gauge or larger wire. Where other grounded objects are available, they also should be connected. Driven rods frequently have high resistance to ground which may cause dangerous potentials to exist on the connected carrier equipment when lightning strikes the cable line or when the cable line accidentally becomes crossed with high-voltage power wires. Do everything possible to reduce the common ground resistances for this equipment. When there is a possibility of high ground resistance, place a platform of dry wood or other suitable insulating material in front of, and under the equipment, to insulate the operating personnel and equipment from the ground. If no such platform is available, chicken wire or other metallic screening spread in front of the equipment and well connected to the equipment ground terminal will help to keep the ground and equipment at about the same potential. This reduces the likelihood of shock to operating personnel standing on the wire and touching the equipment.

Caution: *If it is necessary to change protector blocks or wiring to the binding posts during lightning storms, use rubber gloves or insulated pliers.*

e. When driving ground rods, be careful to place them where there will be good contact between rods and soil. Strike the rods with a driving hammer only hard enough to have them penetrate the soil to the desired depth. In this way slipping of the rod, which would cause poor contact between soil and rod, will not result. A good earth ground connection usually can be established by following the procedure outlined below:

(1) Select the lowest, dampest site in the vicinity, preferably in clay or loamy soil.

(2) Scoop out a small hole about 6 inches deep in the selected location.

(3) Drive a rod which is free from paint or grease into the hole until the top of the rod is approximately 3 inches above the bottom of the hole.

(4) Clamp the lead wire securely to the rod. Saturate the earth around the rod with water and

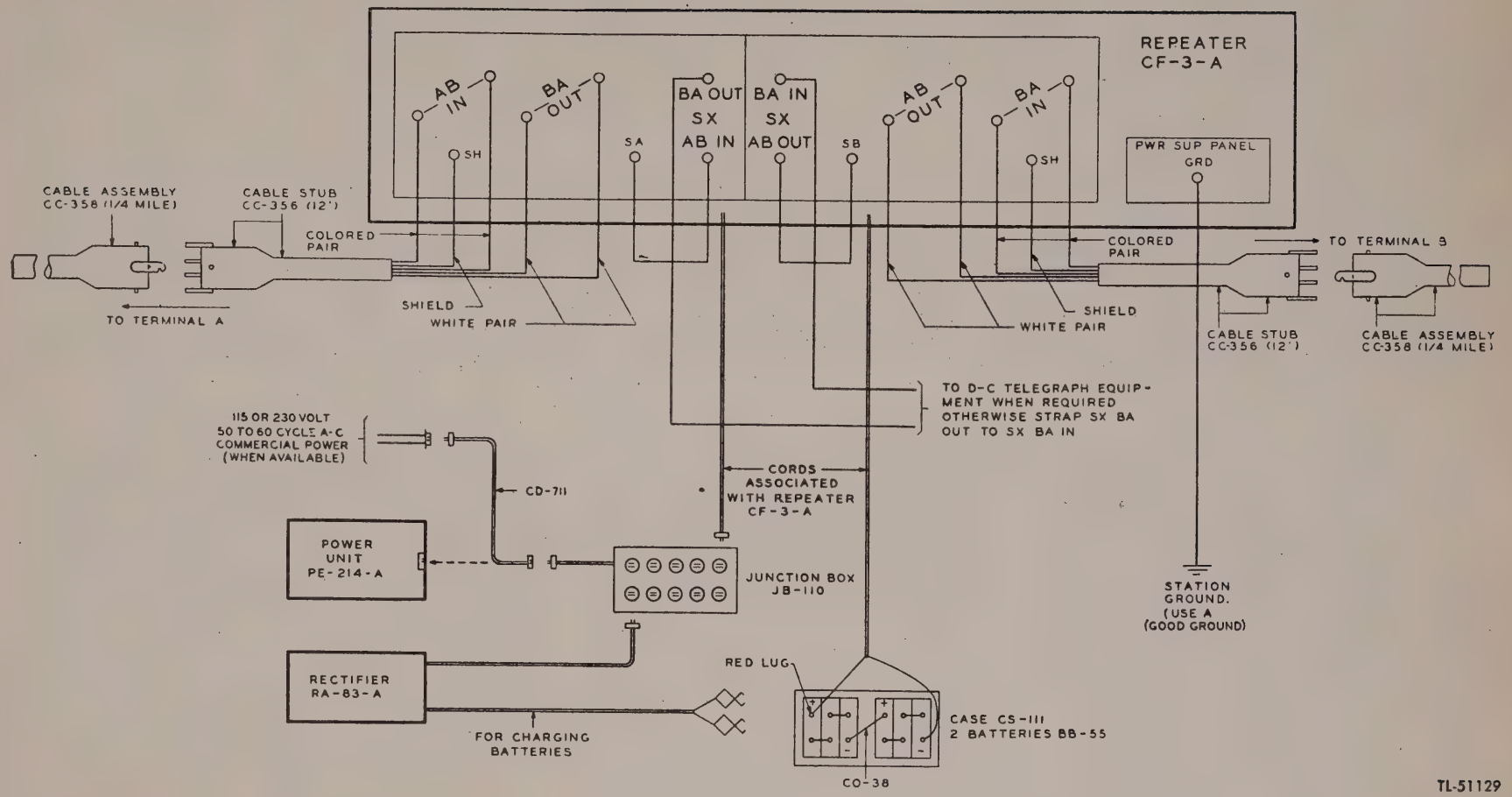


Figure 42. Carrier repeater, cording diagram.

fill in the hole with excavated earth, covering the top of rod. Keep the earth around the rod moist by frequent applications of water.

(5) If satisfactory low ground resistance is not obtained with one rod, drive additional rods in parallel, using the procedure described in (2) to (4) above. Spacing between adjacent rods should not be less than 10 feet.

(6) If multiple ground rods in parallel fail to provide adequate low ground resistance, treat the soil around the rods. Dig a basin 3 feet in diameter and 1 foot deep around each rod. Mix a solution of 5 pounds of salt and 5 gallons of water for each rod. Pour this solution into the basin. In half an hour, or as soon as the solution has seeped through the soil, check connections and fill the basin with the excavated soil, packing it in tightly.

(7) When soil is frozen its resistance is extremely high, and therefore it is necessary to locate the ground rods below the frost level. If it is not possible to drive a long rod to a sufficient depth to obtain a good ground connection, dig or blast a hole below the frost level and drive a rod in the hole until the top of the rod is approximately 3 inches above the bottom of the hole. Clamp the lead wire securely to the rod and fill the hole with the excavated earth or insulating material. This will prevent the earth around the rod from freezing.

Note.—For communication circuits use a metallic return circuit for each line in locations where satisfactory low ground resistance cannot be obtained by the methods outlined above.

63. Connections to the Line and Other Equipment

The external connections to the equipment are shown on the system diagrams mounted inside the front covers of the terminal and repeater equipments. (See figs. 79, 80, 81, 85, 89, 92, and 94.) The external wiring such as cable stubs, power cables, etc., should be brought into and out of the case through the outlet provided in the side of the case for this purpose. This allows the covers to be put in place during operation if necessary. In some locations it may be necessary to thoroughly close the space left in the outlet after all wiring has been placed to prevent insects, mice, etc., from entering the case. This may be done by packing steel wool or similar substance in the outlet. The connections described in paragraphs 64 to 67 must be made before starting line-up of the equipment.

64. Connections for Telephone Terminals CF–1–A and CF–1–B

a. Connect the GRD binding post on the right-hand side of the PWR SUP B panel to ground. The GRD binding posts of the PWR SUP A and PWR SUP B panels are interconnected internally by bay wiring.

b. Check the protectors to insure that the carbon blocks are clean. The blocks may be cleaned by rubbing the flat surfaces together or by rubbing the surfaces with an abrasive cloth. Reinsert the carbon blocks.

c. Throw the lever of the BATTERY-GROUND key on the talk and signal panel to GROUND.

d. Disconnect Cable Stub CC–356 from Cable Assembly CC–358 at the first connector. Connect the cable stub to the terminal equipment as follows:

(1) Connect the *white* pair to the TRSG binding posts.

(2) Connect the *colored* pair to the REC binding posts.

(3) Connect the shield lead to the SH binding post.

e. Make the following connections at *terminal A:*

(1) Connect the SX–TRSG binding post to the SIG binding post.

(2) Connect the SX–REC binding post to the telegraph equipment (if used) assigned to the spare simplex circuit.

f. Make the following connections at *terminal B:*

(1) Connect the SX–REC binding post to the SIG binding post.

(2) Connect the SX–TRSG binding post to the telegraph equipment assigned to the spare simplex circuit.

g. Recouple the cable stub to the connector of the first Cable Assembly CC–358.

65. Channel Terminations of Telephone Terminal CF–1–A

When using Telephone Terminal CF–1–A, make connections to the carrier channels as outlined below:

a. At both terminals A and B connect the CH1, CH2, and CH4 binding posts to the LINE binding posts of the ringing equipment associated with the three circuits or to other circuits as specified.

b. Connect the SWBD binding posts of the ringing equipment to the switchboard as required.

c. Connect the CH3 binding posts to the voice-

frequency telegraph equipment, if such equipment is used. If this channel is used for telephone service, however, connect to the ringing equipment or to another circuit as discussed in paragraph 64.

d. If a five-pair cable is used between the switchboard and ringers, the fifth pair can be connected to a field telephone set or otherwise arranged for communicating between the carrier terminal and the switchboard.

Note.—If all of the five pairs are not used for this purpose, it is not recommended that the extra pair or pairs be used for other purposes, such as for d-c telegraph, which might introduce noise in the telephone channels. If a five-pair cable is not used, twisted pairs should be used for these connections.

e. At both terminals A and B connect a field telephone set to the TEL binding posts on the SIG panel for communication between the carrier terminals and repeaters.

66. Channel Terminations of Telephone Terminal CF–1–B

When using Telephone Terminal CF–1–B make connections to the carrier channel as outlined below, depending upon whether the channel in question is terminated on a two-wire or four-wire basis. If a channel is terminated on a two-wire basis, follow the procedure in *a* below. If a channel is terminated on a four-wire basis, follow the procedure outlined in *b* below.

a. Channels Terminated on a Two-wire Basis. (1) Connect the CHANNELS–2W or 4W TRANSMITTING binding posts of the channel under consideration to the LINE binding posts of the associated ringing equipment or to other equipment as specified.

(2) Note that the associated CHAN 2 WIRE–4 WIRE key on the talk and signal panel is in the 2 WIRE (normal) position.

(3) Set the GAIN potentiometer on the channel on step 21.

b. Channels Terminated on a Four-Wire Basis. Connections for terminating a channel on a four-wire basis, according to the type of equipment connected to the channel under consideration, are given below. Complete connecting information is given for each case. The connections are listed in step-by-step procedures, which should be followed in the order indicated. *Follow each step carefully.*

(1) Connections for extending a channel of one Telephone Terminal CF–1–B over a channel of another Telephone Terminal CF–1–B on a four-wire basis:

Step	Connect from binding post of one Telephone Terminal CF–1–B	Connect to binding post of other Telephone Terminal CF–1–B
1	CHANNELS-2W OR 4W TRANSMITTING.	CHANNELS-4W RECEIVING.
2	CHANNELS-4W RECEIVING.	CHANNELS-2W OR 4W TRANSMITTING.
3	Remove key guards of associated CHAN 2 WIRE-4 WIRE keys at each terminal and throw key levers to 4 WIRE. Replace key guards.	
4	Set GAIN potentiometer on associated channels on step 27.	

(2) Connections for operating a two-, four-, or six-channel, four-wire voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6:†

Step	Connect from binding post of one Telephone Terminal CF–1–B	Connect to binding post of other Telephone Terminal CF–1–B
1	CHANNELS-2W OR 4W TRANSMITTING.	LINE 2 (at terminal A).
		LINE 1 (at terminal B).
2	CHANNELS-4W RECEIVING.	LINE 1 (at terminal A).
		LINE 2 (at terminal B).
3	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE-4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
4	Telephone Terminal CF–1–B: set GAIN potentiometer on channel panel on step 21.	

† Connections for operating a two-, four-, or six-channel, four-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–A and/or Telegraph Terminal CF–6 are identical with those used when Telegraph Terminal CF–2–B and/or Telegraph Terminal CF–6 are used, but corresponding binding post on Telegraph Terminal CF–2–A are marked differently than those on Telegraph Terminal CF–2–B. The T and R binding posts on bay 1 of Telegraph Terminal CF–2–A correspond to the LINE 1 binding posts on Telegraph Terminal CF–2–B, and the T and R binding posts on bay 2 of Telegraph Terminal CF–2–A correspond to the LINE 2 binding post of Telegraph Terminal CF–2–B.

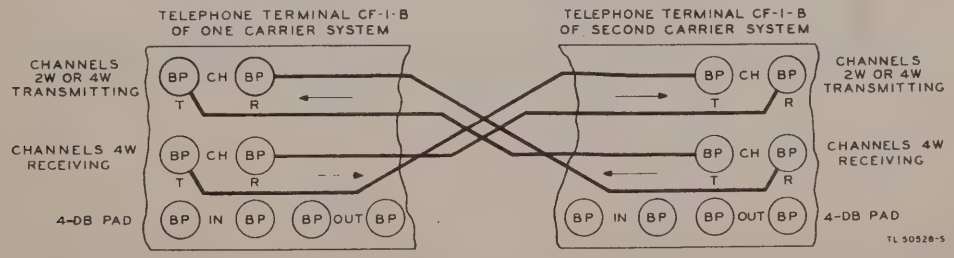


Figure 43. Connections for extending a channel of one Telephone Terminal CF–1–B over a channel of another Telephone Terminal CF–1–B on a four-wire basis.

(3) Connections for operating an eight-channel, four-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6:†

Step	Connect from binding posts	Connect to binding posts
1	CHANNELS–2W OR 4W TRANSMITTING (CF–1–B).	ONE 4 DB PAD OUT (CF–1–B).
2	ONE 4 DB PAD IN (CF–1–B).	LINE 2 (CF–2–B or CF–6, terminal A). LINE 1 (CF–2–B or CF–6, terminal B).
3	CHANNELS–4W RECEIVING (CF–1–B).	LINE 1 (CF–2–B or CF–6, terminal A). LINE 2 (CF–2–B or CF–6, terminal B).
4	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
5	Telephone Terminal CF–1–B: set GAIN potentiometer on channel panel on step 21.	

†See footnote on page 47.

(4) Connections for operating a 12-channel, 4-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6:†

Step	Connect from binding posts	Connect to binding posts
1	CHANNELS–2W OR 4W TRANSMITTING (CF–1–B).	4 DB PAD NO. 2 OUT (CF–1–B).
2	4 DB PAD NO. 2 IN (CF–1–B).	4 DB PAD NO. 1 OUT (CF–1–B).
3	4 DB PAD NO. 1 IN (CF–1–B).	LINE 2 (CF–2–B or CF–6, terminal A). LINE 1 (CF–2–B or CF–6, terminal B).
4	CHANNELS–4W RECEIVING (CF–1–B).	LINE 1 (CF–2–B or CF–6, terminal A). LINE 2 (CF–2–B or CF–6, terminal B).
5	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
6	Telephone Terminal CF–1–B: set GAIN potentiometer on channel panel on step 21.	

†See footnote on page 47.

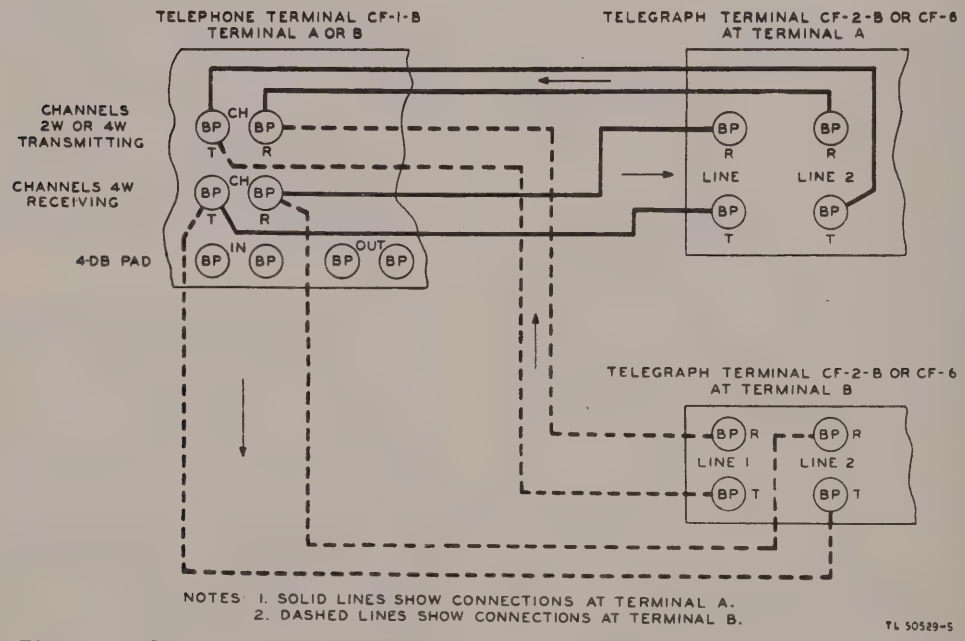


Figure 44. Connections for operating a two-, four-, or six-channel, four-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6.

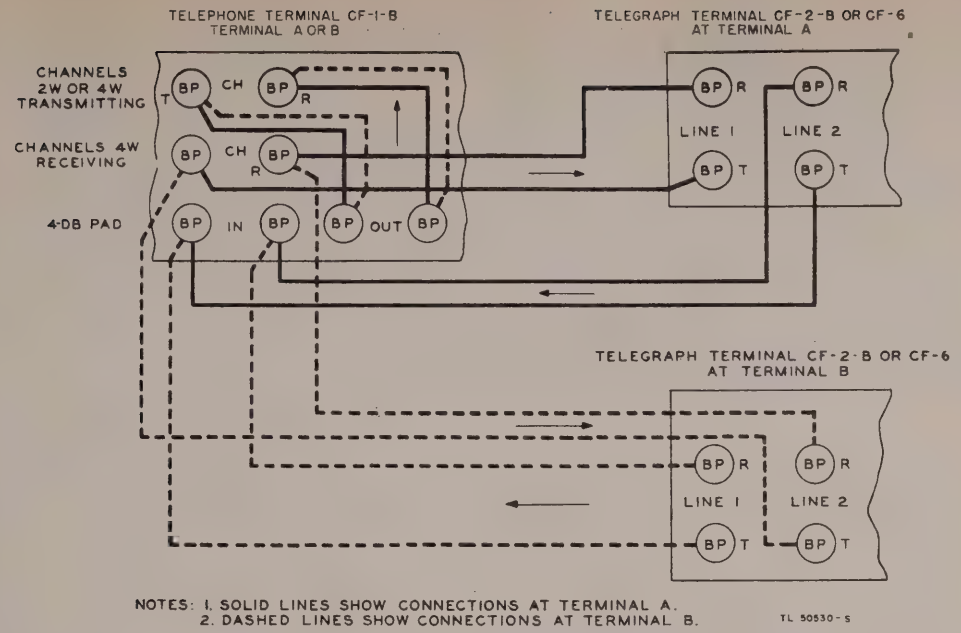


Figure 45. Connections for operating an eight-channel, four-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6.

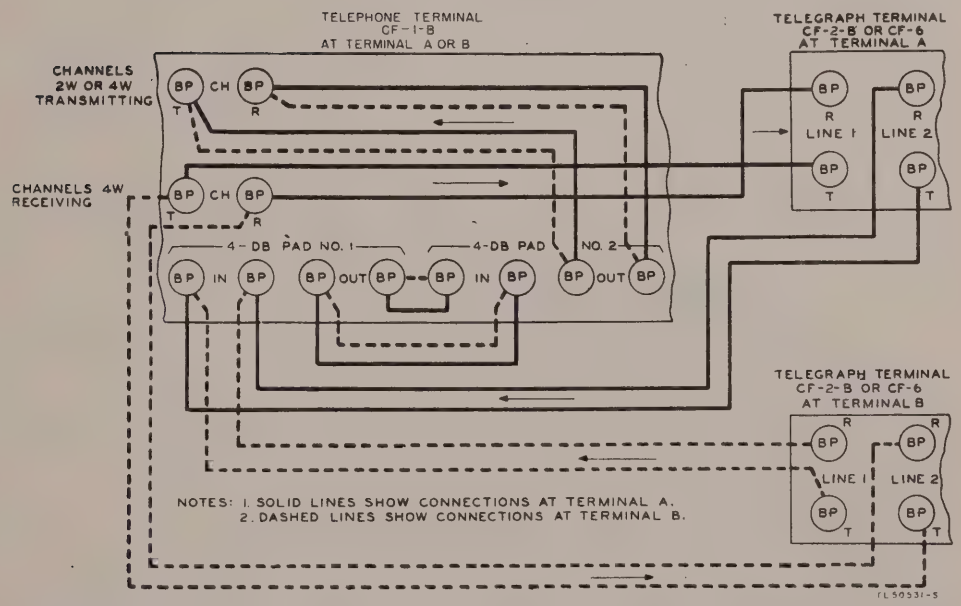


Figure 46. Connections for operating a 12-channel, 4-wire, voice-frequency telegraph system using Telegraph Terminal CF–2–B and/or CF–6.

(5) Connections for operating a six-channel, four-wire, voice-frequency carrier telegraph system using Carrier Terminal OA–4/FC or OA–5/FC (voice-frequency carrier telegraph terminal X–61822–A or X–61822–B):

Step	Connect from binding posts	Connect to terminals
1	CHANNELS–2W OR 4W TRANSMITTING (CF–1–B).	SEND LT and SEND LR at top of bay No. 1 or 3 (OA–4/FC or OA–5/FC).
2	CHANNELS–4W RECEIVING (CF–1–B).	REC LT and REC LR at bottom of bay No. 1 or 3 (OA–4/FC or OA–5/FC).
3	Restrap pad at top of Carrier Terminal OA–4/FC or OA–5/FC bay No. 1 or 3 for 7-db loss by removing existing straps and strapping terminals 1 to 3, 4 to 5, 6 to 7, and 8 to 15 on terminal strip on top panel at rear of bay.	
4	At Telephone Terminal CF–1–B remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
5	Telephone Terminal CF–1–B: set GAIN potentiometer on channel panel on step 21.	

(6) Connections for operating a 12-channel, 4-wire, voice-frequency, carrier telegraph system using Carrier Terminal OA–4/FC or OA–5/FC (voice-frequency carrier telegraph terminal X–61822–A or X–61822–B):

Step	Connect from binding posts	Connect to terminals
1	CHANNELS–2W OR 4W TRANSMITTING (CF–1–B).	SEND LT and SEND LR at top of bay No. 1 (OA–4/FC or OA–5/FC).
2	CHANNELS–4W RECEIVING (CF–1–B).	REC LT and REC LR at bottom of bay No. 1 (OA–4/FC or OA–5/FC).
3	Restrap pad at top of Carrier Terminal OA–4/FC or OA–5/FC bay No. 1 for 15-db loss by removing existing straps and strapping terminals 1 to 3, 4 to 5, 6 to 7, 8 to 9, 10 to 11, and 12 to 15 on terminal strip on top panel at rear of bay.	
4	Carrier Terminal OA–4/FC or OA–5/FC bay No. 1: remove input pad T from circuit. This pad is located on rear of top panel of bay to right of coil R. Strap terminals 1 and 3 of the pad together. Disconnect wires from terminal 2 of the pad and connect these wires together. Tape joint. Tag the pad, noting on tag that pad is disconnected and steps to be taken to reconnect it. Tag wires removed from pad, noting that they have been removed from terminal 2 or pad T.	
5	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
6	At Telephone Terminal CF–1–B: set GAIN potentiometer on channel panel on step 21.	

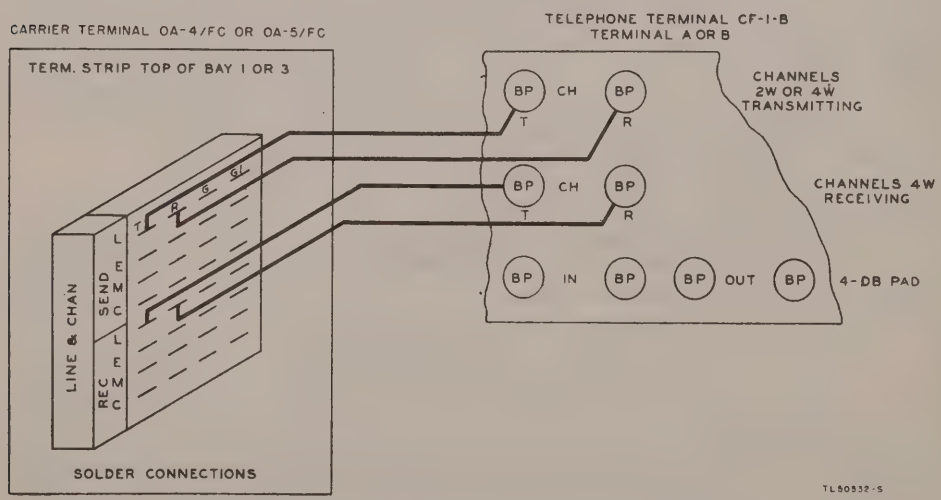


Figure 47. Connections for operating a six-channel, four-wire, voice-frequency carrier telegraph system, using Carrier Terminal OA–4/FC or OA–5/FC.

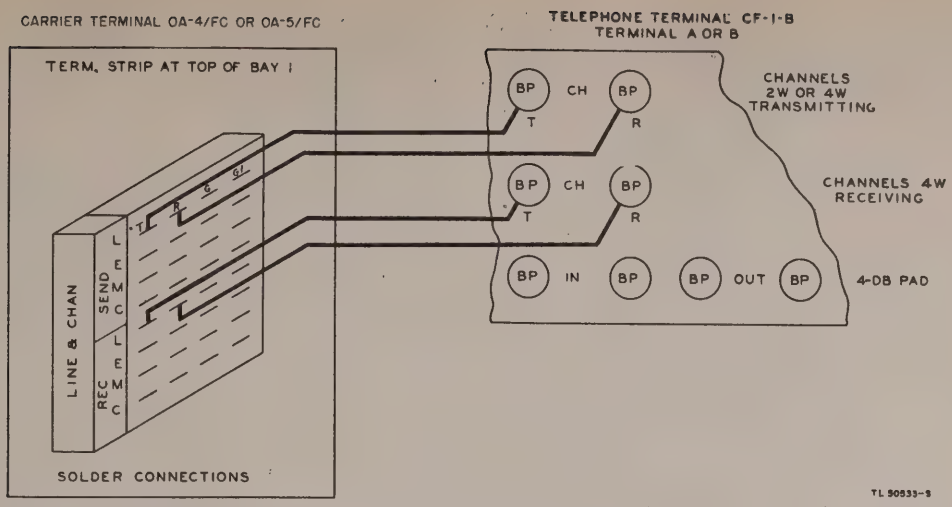
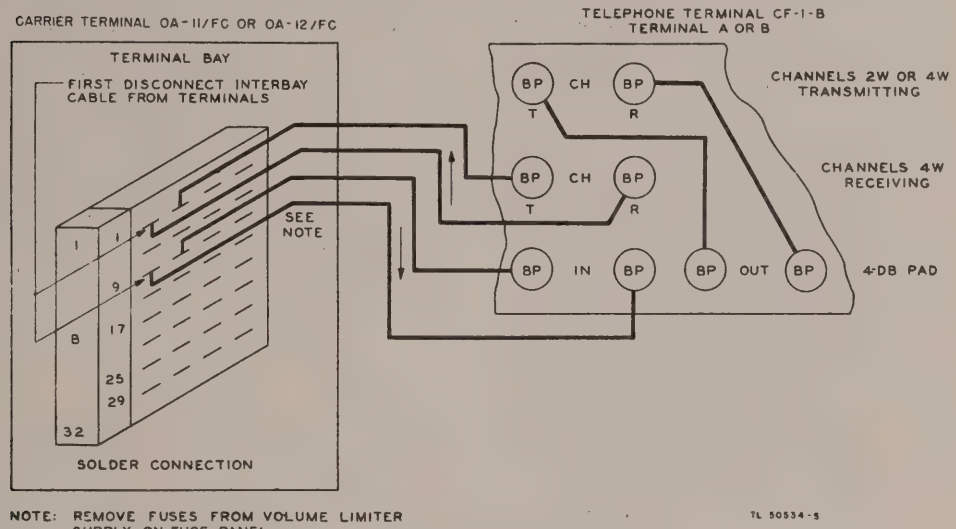


Figure 48. Connections for operating a 12-channel, 4-wire, voice-frequency carrier telegraph system, using Carrier Terminal OA–4/FC or OA–5/FC.



NOTE: REMOVE FUSES FROM VOLUME LIMITER SUPPLY ON FUSE PANEL.

Figure 49. Connection for extending a channel of Telephone Terminal CF–1–B over channel 1 of Carrier Terminal OA–11/FC or OA–12/FC.

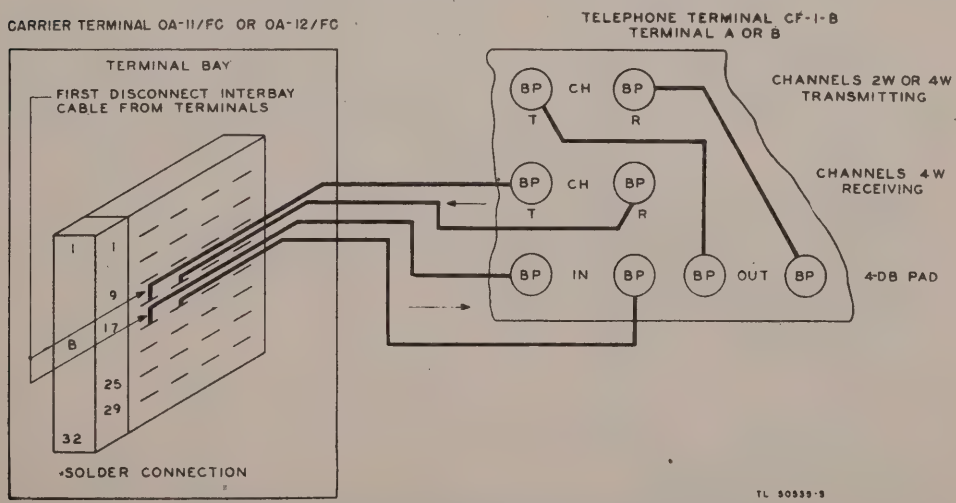


***Figure** 50. Connections for extending a channel of Telephone Terminal CF–1–B over channel 2 of Carrier Terminal OA–11/FC or OA–12/FC.*

(7) Connections for extending a channel of Telephone Terminal CF–1–B over a channel of Carrier Terminal OA–11/FC or OA–12/FC (C carrier east terminal X–61819P or C carrier west terminal X–61819R):

To connect a channel of Telephone Terminal CF–1–B to Carrier Terminal OA–11/FC or OA–12/FC channel	Step	Procedure
1 (fig. 49)	1	Carrier Terminal OA–11/FC or OA–12/FC: disconnect interbay cable from terminals 1, 2, 9, and 10 on terminal strip B at top of terminal bay.
	2	Telephone Terminal CF–1–B: connect CHANNELS–2W or 4W TRANSMITTING binding posts to one set of 4 DB PAD OUT binding posts.
	3	Connect one set of 4 DB PAD IN binding posts of Telephone Terminal CF–1–B to terminals B9 and B10 at top of bay of Carrier Terminal OA–11/FC or OA–12/FC.
	4	Connect CHANNELS–4W RECEIVING binding posts of Telephone Terminal CF–1–B to terminals B1 and B2 at top of bay of Carrier Terminal OA–11/FC or OA–12/FC.
	5	Carrier Terminal OA–11/FC or OA–12/FC: remove fuses for channel 1 volume limiter on fuse panel.
	6	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE.
	7	Telephone Terminal CF–1–B: set GAIN potentiometer on associated channel panel on step 14.
2 (fig. 50)	1	Carrier Terminal OA–11/FC or OA–12/FC: disconnect interbay cable from terminals 13, 14, 17, and 18 on terminal strip B at top of terminal bay.
	2	Telephone Terminal CF–1–B: connect CHANNELS–2W OR 4W TRANSMITTING binding posts to one set of DB PAD OUT binding posts.
	3	Connect one set of 4 DB PAD IN binding posts of Telephone Terminal CF–1–B to terminals B17 and B18 at top bay of Carrier Terminals OA–11/FC or OA–12/FC.
	4	Connect CHANNELS–4W RECEIVING binding posts of Telephone Terminal CF–1–B to terminals B13 and B14 at top of bay of Carrier Terminal OA–11/FC or OA–12/FC.
	5	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.
	6	Telephone Terminal CF–1–B: set GAIN potentiometer on associated channel panel on step 14.

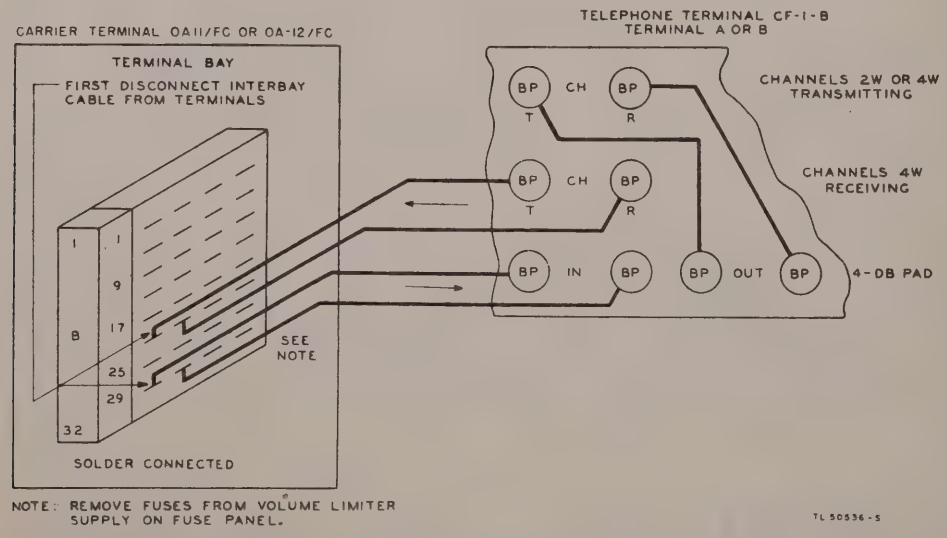


Figure 51. Connections for extending a channel of Telephone Terminal CF–1–B over channel 3 of Carrier Terminal OA–11/FC or OA–12/FC.

To connect a channel of Telephone Terminal CF–1–B to Carrier Terminal OA–11/FC or OA–12/FC channel	Step	Procedure
3 (fig. 51)	1	Carrier Terminal OA–11/FC or OA–12/FC: disconnect interbay cable from terminals 21, 22, 29, and 30 on terminal strip B at top of terminal bay.
	2	Telephone Terminal CF–1–B: connect CHANNELS-2W OR 4W TRANSMITTING binding posts to one set of 4 DB PAD OUT binding posts.
	3	Connect one set of 4 DB PAD IN binding posts of Telephone Terminal CF–1–B to terminals B29 and B30 at top of bay of Carrier Terminal OA–11/FC or OA–12/FC.
	4	Connect CHANNELS-4W RECEIVING binding posts of Telephone Terminal CF–1–B to terminals B21 and B22 at top of bay of Carrier Terminal OA–11/FC or OA–12/FC.
	5	Carrier Terminal OA–11/FC or OA–12/FC: remove fuses for channel 3 volume limiter on fuse panel.
	6	Telephone Terminal CF–1–B: remove key guard of associated CHANNEL 2 WIRE-4 WIRE key and throw key lever to 4 WIRE. Replace key guard.
	7	Telephone Terminal CF–1–B: set GAIN potentiometer on associated panel on step 14.

(8) Connections for extending a channel of Telephone Terminal CF–1–B over Carrier Terminal OA–13/FC (H carrier terminal X–66217A):

Step	Connect from binding posts of Telephone Terminal CF–1–B	Connect to terminals on terminal strip A of Carrier Terminal OA–13/FC
1	CHANNELS-2W OR 4W TRANSMITTING to one set of 4 DB PAD OUT binding posts.	
2	One set of 4 DB PAD IN binding posts.	11 and 12
3	CHANNELS-4W RECEIVING.	9 and 10
4	Carrier Terminal OA–13/FC: operate EQPT switch to 4W TLG instead of 4W TEL.	
5	Telephone Terminal CF–1–B: remove key guard of associated CHAN 2 WIRE–4 WIRE key and throw key lever to 4 WIRE. Replace key guard.	
6	Telephone Terminal CF–1–B: set GAIN potentiometer on associated channel panel on step 23.	

67. Connections for Repeater CF–3–A

a. Connect the GRD binding post on the right side of the PWR SUP panel to ground. Check to be sure that the carbon protector blocks are clean, and reinsert them in the protector mountings.

b. Connect Cable Stubs CC–356 to the repeater equipment in the following manner. If the cable stubs are already connected to the connectors of the first Cable Assemblies CC–358 on either side of the repeater, they should be disconnected before making the following connections:

(1) Connect the SX AB IN binding post to the SA binding post and the SX AB OUT binding post to the SB binding post.

(2) When telegraph service is provided at the

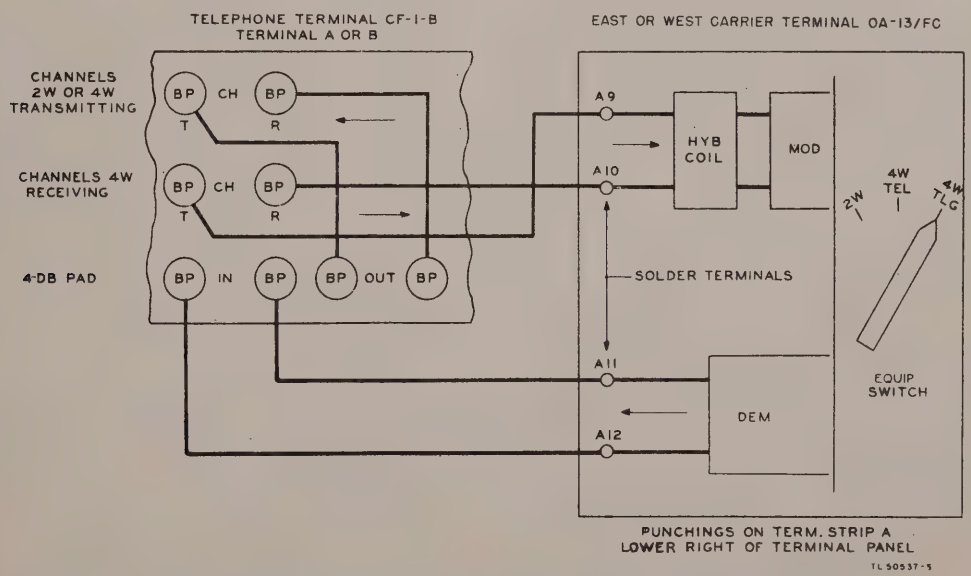


Figure 52. Connections for extending a channel of Telephone Terminal CF–1–B over Carrier Terminal OA–13/FC.

repeater point, connect the telegraph set as specified. Where no telegraph equipment is provided, connect the SX BA OUT binding post to the SX BA IN binding post.

(3) Using the first cable stub, connect the *white* pair to the BA OUT binding posts. Connect the *colored* pair to the AB IN binding posts. Connect the shield lead to the adjacent SH binding post.

(4) Using the second cable stub, connect the *white* pair to the AB OUT binding posts. Connect the *colored* pair to the BA IN binding posts. Connect the shield lead to the adjacent SH binding post.

(5) Couple the cable stub connected in (3) above, to the cable assembly going towards terminal A.

(6) Couple the cable stub connected in (4) above, to the cable assembly going towards terminal B.

68. Connections for Telephone Terminal CF–1–A Arranged for Four-wire Operation

a. Figure 53 is a schematic diagram of field arrangement of a channel of Telephone Terminal CF–1–A for four-wire operation.

b. Four-wire connections can be made between channels 2, 3, or 4 arranged for four-wire operation and any of the following: a similar channel of another carrier system, any other telephone circuit arranged for four-wire operation, or other types of communication facilities, such as a radio system, that are normally designed for four-wire operation.

c. The only additional equipment ordinarily required to arrange Telephone Terminal CF–1–A for four-wire operation is one Coil C–161, a 600-ohm resistor, the resistors for the 3-db or 6-db pad shown in figure 53, the necessary wire, and a soldering iron. The 3-db or 6-db pad should be installed as described in *e* below.

d. Attach Coil C–161 by screws to the side of the case of Telephone Terminal CF–1–A adjacent to the panel of the channel to be adapted for four-wire operation (at the right-hand side when the operator is looking at the rear of the panel).

e. Unsolder and disconnect the wires now connected to terminals 1 and 2 of the repeating coil H. Solder lengths of Wire W–69–A to the wires removed from terminals 1 and 2 of repeating coil H and tape the splice. Connect these wires to the 3-db or 6-db pad or onto Coil C–161 as shown in figure 53. Connect a 600-ohm resistor to terminals 1 and 2 of repeating coil H to terminate this winding.

f. The resistors for either the 3-db or the 6-db pad should be tied securely to the panel resistance support mounting. Run a wire from the resistors to the switchboard binding posts of Coil C–161.

g. Carefully insulate the resistors and the wiring from the other equipment and wiring located near them.

h. Connect the transmitting branch of the external circuit to the LINE binding posts of Coil C–161.

i. Connect the receiving branch of the external circuit to the CH binding posts of the channel arranged for four-wire operation.

j. If the line extends a distance from the carrier terminal (½ mile to 1 mile or more), provide line cut-out protectors at both ends of the external circuit to safeguard equipment and personnel. The protectors are required in both the transmitting and receiving branches.

k. Be sure to tag Telephone Terminal CF–1–A indicating clearly which channel was arranged for four-wire operation and the nature of the changes made.

69. Connections for Carrier Hybrid CF–7

Figure 36 shows the balanced two-wire carrier hybrid system. Binding posts are provided on Carrier Hybrid CF–7 for all external connections. The 2W LINE binding posts are for connection to the two-wire line. The TRSG and REC binding posts are for connecting to Telephone Terminal CF–1–(*) or Repeater CF–3–A. Binding post PH is for making connections to the phantom circuit and normally is connected to the GRD (ground) binding post by a removable metal link. Two other binding posts marked EXT NET are for connecting an external network into the balancing network circuit. A soft rubber gasket between the box and cover permits the connecting wires to be brought out with the cover closed. For detailed instructions for use of Carrier Hybrid CF–7, see TM 11–2003.

70. Open-wire Connections

The method of setting up the spiral-four system on two-open wire pairs is the same as for the normal spiral-four system, except that typical equalizer settings must be determined as outlined in paragraph 42.

71. Pair-per-System Connections

Normally in the regular spiral-four system, connections are made by connecting the TRSG binding posts of terminal A to the REC binding

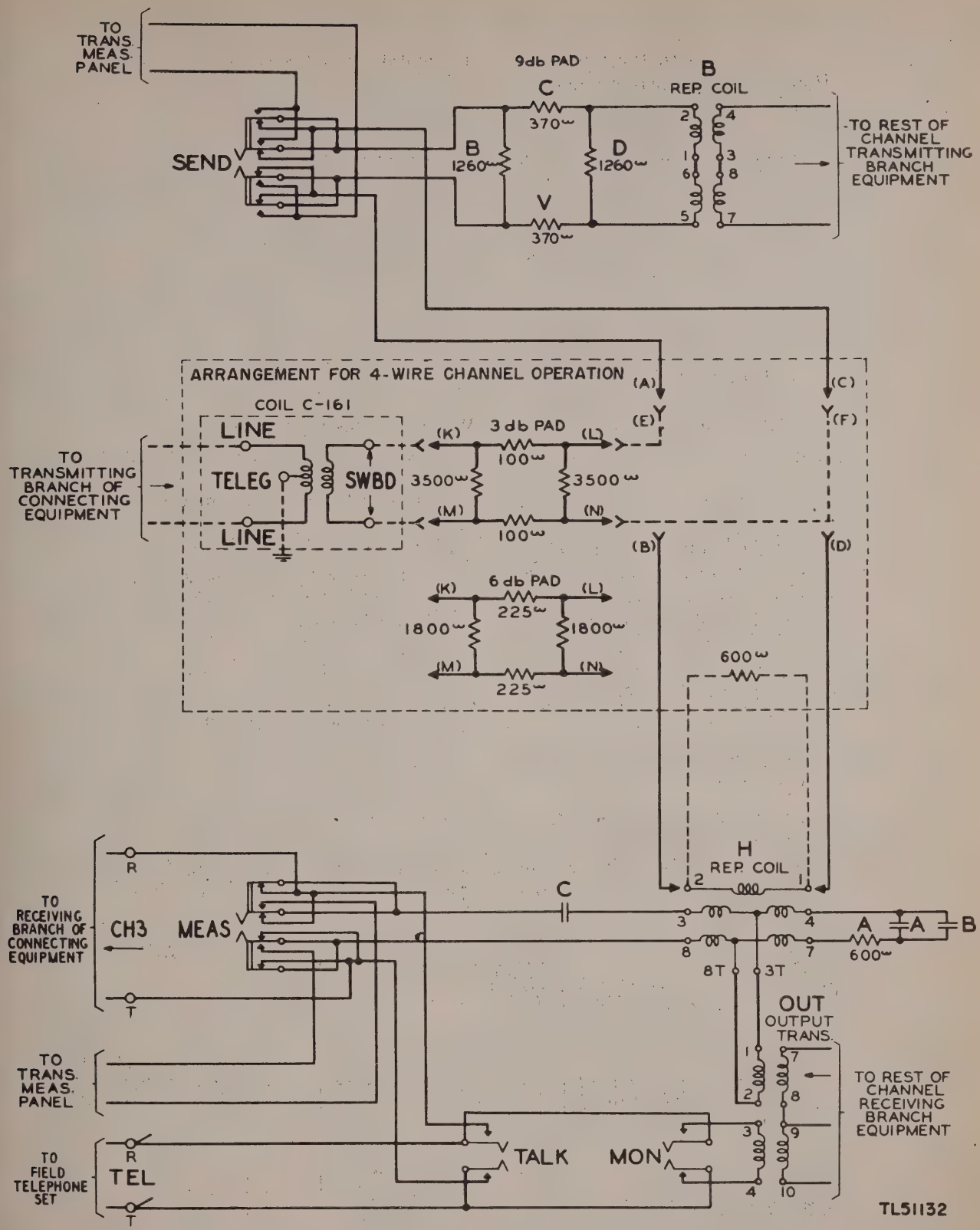


Figure 53. Telephone Terminal CF–1–A, field arrangement for four-wire operation, schematic diagram.

posts of terminal B with one pair of wires, and the REC binding posts of terminal A to the TRSG binding posts of terminal B with the other pair of spiral-four. However, in pair-per-system operation, the TRSG binding posts of terminal A are connected by a single open-wire pair to the TRSG binding posts of terminal B. The REC binding posts of terminal A are connected to the open wire running from terminal A to terminal B at terminal A. The REC binding posts of terminal B are connected to the open wire running from terminal A to terminal B at terminal B.

72. Open-wire Converter System Connections

The open-wire converter system uses Telephone Terminal CF–1–(*), Converter CF–4 (Carrier, 2-wire-4-wire), and Repeater CF–5 (Carrier, 2-wire). Telephone Terminal CF–1–(*) is connected over two pairs to Converter CF–4 and then to the open-wire line.

73. Radio Relay Connections

The pair coming from the TRSG binding posts of telephone terminals A and B are connected to the transmitter of the associated radio relay sets, and the pair from the REC binding posts of both telephone terminals are connected to the radio receivers of the associated radio relay sets. Detailed information on the use of a radio relay is contained in TM 11–2601.

74. Connections for Extension Circuits at Repeaters

a. Make the wiring connections shown in figure 54. The handset of Repeater CF–3–A is normally connected to a terminal block on the back of the TALK and SIG panel. Remove these connections, leaving the handset cord in place, and tape the terminals on the cord to prevent accidental contact with other wiring.

b. If the extension telephone is not at or very close to the repeater, provide line cut-out protectors in the extension line at the repeater and at the telephone to protect personnel and equipment from lightning. Be sure to tag the repeater clearly, indicating the nature of the modification.

75. Connections When Channels Are Dropped at Intermediate Points

Since Telephone Terminal CF–1–B may be operated on a four-wire basis, the procedures involved are somewhat different from those for connections for Telephone Terminal CF–1–A. The two methods are given in *a* and *b* below. When it is desired to drop or bridge onto one or more of the four channels of the carrier system at an intermediate point, it will be necessary to provide two telephone terminals at the dropping or bridging point. The two terminals are operated back to back, and any of the channels may be dropped, bridged onto, or carried through by interconnections at the channel binding posts. In this way a single system becomes two systems working in tandem.

a. Connections for Telephone Terminal CF–1–A. The individual channels of two Telephone Terminals CF–1–A may be connected as follows: From one to the other for through connections; to local stations or switchboards for connections brought out and dropped; connected through, with local extensions bridged on as desired. Voice-frequency ringers are not required on circuits carried through, but are necessary on all extensions dropped or bridged.

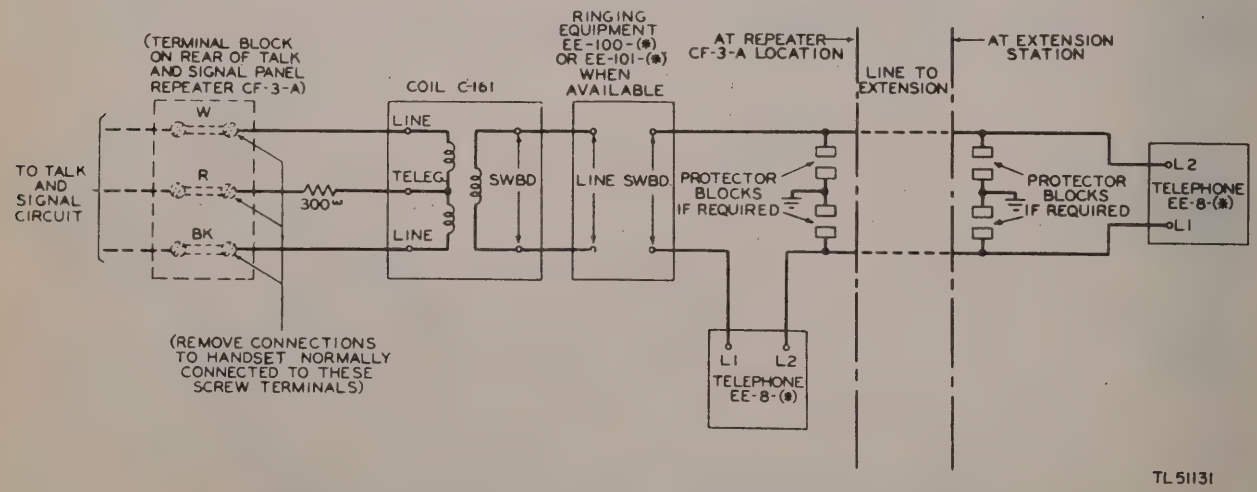


Figure 54. Connections for bridged extension telephone at a repeater.

b. Connections for Telephone Terminals CF–1–B. The two Telephone Terminals CF–1–B should be located as close together as possible. When a bridge is connected on a channel, the distance between the adjacent terminals should not be more than 500 feet as the two-wire balance of the two-channel terminations may be reduced, causing a singing or near singing condition.

(1) *Through channels using adjacent Telephone Terminals CF–1–B or Carrier Terminal OA–11/FC or OA–13/FC.* Connect the channels of the two systems together on a four-wire basis as outlined in paragraph 66*b* (7) and (8).

(2) *Through channels using one Telephone Terminal CF–1–A and one Telephone Terminal CF–1–B.* Connect the channels of the two systems together on a two-wire basis according to instructions in paragraphs 65 and 66*a*.

(3) *Through channels with bridging extensions.* When bridging extensions are required, the channels of the two systems must be connected together on a two-wire basis as provided in paragraph 49.

c. General. Telegraph terminals are not required if no telegraph channels are to be dropped off or carried through an intermediate teletypewriter set at the dropping point. In this case the carrier telephone channel used for telegraph is carried through by the interconnections between the channel binding posts or the two telephone terminals. Telegraph terminals are required if one or more telegraph channels are to be dropped off or carried through an intermediate station. These telegraph terminals are connected to the telephone terminal binding posts of the channel used for telegraph. Those channels of the telegraph system which are not dropped off or carried through an intermediate teletypewriter set are carried through by interconnecting the respective d-c loop binding posts of the telegraph terminals.

76. Periodic Check of Vacuum Tubes

a. All vacuum tubes used in Telephone Terminal CF–1–(*) and Repeater CF–3–A should be tested before placing the equipment in service and at least once each month. Make the tests with Tube Tester I–177. This test set can only be used where a 105- to 125-volt, 50- to 60-cycle a-c power supply is available. Tube Tester I–177 is described in TM 11–2627.

b. Dial settings required in testing Tube VT–107–A (6V6GT) and Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT) are given in the chart included with the tube tester. The settings are given in table VII.

Table VII.—Dial settings on tube tester I–177 for testing vacuum tubes

Tube	A	B	FIL	L	R
Tube VT–107–A (6V6GT)	8	5	6.3	67	25
Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT)	4	2	6.3	56	18

c. The tests to be made and the rejection limits are as follows:

(1) *Short test.* Reject the tube if the lamp lights.

(2) *Transconductance test.* Reject the tube if the meter reads REPLACE.

(3) *Grid current test.* Reject the tube if the meter reading increases over two scale divisions.

d. A filament activity test of Tube VT–116 may be made if Test Set I–171 is available. There is no provision in Tube Tester I–177 for making this test. To make the test, use an L dial setting of 56 on Test Set I–171. If the meter reads REPLACE with the FIL ACT key lever thrown, reject the tube.

77. Checking Batteries

Batteries must be in proper condition at all times. Their condition may be determined by reading the specific gravity of each cell. For this purpose, Hydrometer HY–2 is furnished with both Telephone Terminal Set TC–21–(*) and Repeater Set TC–23–A.

a. Check the batteries before placing the equipment in service and at least once each week. If the specific gravity reading on the hydrometer is 1.240 or less for any cell, charge the battery.

b. Check the water levels of the batteries before charging them. If necessary, fill the cells to about ⅜ inch above the tops of the separators. Use distilled or approved water. In extreme cases when approved water is not available, any clear water free from sediment or visible foreign matter may be used. Continued use of such water should be avoided, however, so that soluble salts, damaging to batteries, will not accumulate.

c. Charge Batteries BB–55 from Rectifier RA–83–A or Power Unit PE–201 in accordance with instructions contained in paragraphs 177 and 178. The charge should continue until a specific gravity of 1.270 to 1.300 at 80° F. is reached and remains constant within plus or minus one division of the hydrometer scale for two readings taken ½ hour apart.

d. If a hydrometer is not available, the weekly check may be made by determining the voltage of the battery under load as follows:

(1) Disconnect the a-c power supply to Telephone Terminal CF–1–(*), Repeater CF–3–A, or Ringing Equipment EE–101–A, whichever is connected to the battery under test. This transfers the power supply to the battery. Be sure that the frequency generator (vibrator) starts and that the carrier system is operating.

(2) Allow the equipment to operate from the battery for 15 minutes. This stabilizes the electrolyte. Measure the voltage of the two batteries in series, using the 15-volt scale of Voltohmmeter I–166 or its equivalent. If the voltage is 11.5 volts or below, charge the battery.

(3) To keep a battery active (TM 11–430), charge the battery for short periods at regular intervals regardless of specific gravity or voltage limits. In temperate climates this should be done every 2 months. In hot or tropical climates it should be done once monthly. In cold climates it should be done once in 5 or 6 months. Keep a record of the charging intervals.

e. See table LV for information as to the hours of service to be expected from a fully charged Battery BB–55 before it requires recharging.

78. Checking Relays

a. Relays ordinarily should not require readjustment except for an occasional cleaning of the contacts unless they have been subjected to abuse which has changed their original adjustment. Small particles of lint or dust in the contacts is the most common cause of relay failure, and therefore it is important to keep the relay or panel covers in place at all times.

b. If it is necessary to clean contacts, they should be cleaned with carbon tetrachloride. If the contacts have burrs, they may be smoothed with the burnishing tool furnished with Tool Equipment TE–123 (fig. 12) while the contacts are held closed manually. Two or three movements back and forth across the contacts with light pressure should be sufficient.

c. The relay R is used in the power supply circuit to affect the transfer to emergency battery operation if the regular a-c service fails. The relay in Telephone Terminals CF–1–A with serial numbers 380 and higher differs slightly from the relay in terminals with serial numbers below 380. The relay in Repeaters CF–3–A with serial numbers 723 and higher differs from the relay in those with serial numbers below 723. The same voltage test limits apply to both relays, but the check procedure if the relay fails to operate is somewhat different. (See par. 175.)

(1) The contact pressure of the normally open contacts should be a minimum of 18 grams, and the contact pressure of the normally closed contacts should be a minimum of 10 grams. If the pressure between contact is not satisfactory, it may be adjusted by turning the coil spring adjusting screw and, if necessary, by careful shaping of the flat spring that carries the contacts. The two contacts on the same side of each spring should close at approximately the same time.

(2) The contacts may be cleaned by drawing a fine file or a fine-grained abrasive cloth between the contact while they are held firmly together with the fingers.

(3) The relay should operate on a voltage of 105 volts when the power supply circuit is wired for 110- to 125-volt operation and on a voltage of 210 volts when the power supply circuit is arranged for 220- to 250-volt operation. If the relay does not release when the voltage is disconnected, a check for binding of the armature should be made. (See par. 175.)

(4) For instructions as to the procedure to follow when relay R fails to operate, see paragraph 175.

d. The relay S in the alarm and signaling circuit is used to indicate interruption in the simplex circuit used for signaling. The relay is normally held operated by battery which is applied at one terminal and ground which is applied at the other terminal or at a repeater.

(1) When the relay operates, the bottom contact should close before the armature touches the core. When it releases, the top contact should close before the armature reaches its backstop. The armature travel, that is the gap between the armature and the pole face when the relay is released, should not be greater than 0.029 inch. The relay should operate on a current of 0.0071 ampere and should not operate when a current of 0.0045 ampere is suddenly applied. Operation of the relay on its nonoperate current indicates that the tension of the spring is too light, while failure to operate on its operate current indicates that the tension is too great.

(2) See paragraph 174 if it is necessary to adjust relay S.

79. Checking Capacitors

If the equipment has been stored for any length of time, the electrolytic capacitors B1 and B2

in the power supply panels and, in Telephone Terminal CF–1–B, the 15-volt electrolytic capacitors T in the telephone circuit should be checked. These capacitors may lose their film if the equipment is out of operation for a period of 18 months or more. See paragraph 179 for direction on restoring the film of these capacitors.

80. Preliminary Adjustments

Before placing the system in operation, a system line-up is required in order to obtain the proper equalizer dial settings and to check the operation of the system. Communication between terminals and repeaters is required for this procedure and may be established by the alarm and signaling circuit. Any channel may be used for talking between terminals, but only channel 1 may be used for talking between terminals and repeaters or between repeaters. When a carrier system is being established the repeater points should monitor on the circuit until it is determined that the alarm and signaling circuit is functioning properly. Be careful that not more than one TALK key is thrown at a terminal at the same time. Otherwise, the channels will be connected together. The preliminary adjustments to be made to facilitate the line-up of the system are discussed in paragraphs 81 to 86.

81. Output Key

If the system includes one or more repeaters, the OUTPUT key lever located on the channel 1 panel should be in the NORMAL position at both terminals. Be sure that the key guard is in place. If the system has no repeaters, set the OUTPUT key as shown in table VIII. If the approximate distance is unknown, throw the key lever to its NORMAL position.

Table VIII.—Output key lever setting when system has no repeaters

Distance to other terminal	Position of OUTPUT key lever
Up to 30 miles	NORMAL
30 to 37.5 miles	+5
37.5 to 45 miles	+10

82. Dial Settings

At both terminals set the dials on the equalizer panel in accordance with table IX. The dial settings are also given in the chart mounted on the equalizer panel. If the approximate distance to the adjacent station is unknown, set the dials for a 20-mile spacing.

Table IX.—Equalizer panel settings

Distance from preceding repeater or terminal	Dial settings to be used in advance of system line-up			
	MILES	1	4	2
10 to 15 miles	15	17	3	4
15 to 20 miles	20	21	3	4
20 to 25 miles	25	24	4	4
25 to 30 miles	30	28	4	4
Over 30 miles	30	28	4	4

83. Gain Potentiometers

Set the GAIN potentiometers on the channel panels to step 21.

84. Signaling Circuit, Terminals and Repeaters

a. The following procedure is used in placing the alarm and signaling circuit in operation.

(1) At terminal A, throw the key lever on the signal panel to the BATTERY position.

(2) At terminal B, throw the key lever on the signal panel to the GROUND position.

(3) If the alarm and signaling circuit is continuous from terminal to terminal the signal will sound at all repeaters and at both terminals since the SIGNAL CUTOFF key lever is thrown at all stations.

(4) To signal between terminals and repeaters, throw the key lever on the signal panel or on the talk and signal panel to the SIGNAL position. A prearranged code may be used to indicate the station desired. The key levers should be held thrown for at least 2 seconds for each signaling impulse to assure a good signal at each repeater and distant terminal.

b. The following procedure may be used to establish communication between a terminal and any repeater when the through signaling circuit has not been completely set up at all points. Also, it may be used to restore signaling between the repeaters and one terminal when the cable continuity is broken.

(1) Before the cable continuity is established or when the cable continuity is broken the bell will sound at all stations. To silence the bell throw the key lever on the signal panel to SIGNAL CUTOFF.

(2) Monitor on channel 1 at each station as described in paragraph 85, and at repeater points talk to the terminal when requested. If the cable is broken a repeater will be able to talk to one terminal but not both. This procedure will enable the terminals to determine the repeater section in which the cable is open or in trouble.

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(3) To restore signaling over the remaining section of cable, throw the key levers on the signal panel or the talk and signal panel in accordance with table X.

Table X.—Key settings to restore signaling on broken line

Terminal A	Last repeater between break and terminal A	Last repeater between break and terminal B	Terminal B
Throw key lever to BATTERY position.	Throw GROUND key lever to GROUND B position.	Throw GROUND key lever to GROUND A position.	Throw key lever to BATTERY position.

(4) Silence the signal at all stations by restoring the SIGNAL CUTOFF key lever at the repeaters to the normal position and throw the key lever at terminal B to the GROUND position.

85. Communication Circuit

The procedures for talking and monitoring on Telephone Terminals CF–1–A and CF–1–B differ. For this reason they are described separately in *a* to *c* below.

a. At Telephone Terminal CF–1–A. (1) To monitor on channel 1, throw the key lever on the channel 1 panel to the MON position.

(2) To talk on channel 1, throw the key lever on the channel 1 panel to the TALK position.

(3) To monitor or talk on channels 2, 3, or 4, throw the MON or TALK keys on the channel panels as described for channel 1.

b. At Telephone Terminal CF–1–B, Channel Terminated on a Two-wire Basis. (1) Throw the lever of the TALK-MON key on the panel of the channel over which it is desired to talk or monitor to TALK or MON as required.

(2) Throw the lever of the TEL key on the talk and signal panel to the LINE or 2W SWBD position (normal).

(3) Operate the lever on the handset to talk. To monitor, leave the lever unoperated.

c. At Telephone Terminal CF–1–B, Channel Terminated on a Four-wire Basis. (1) Throw the lever of the TALK-MON key on the panel of the channel over which it is desired to talk or monitor to TALK or MON as required.

(2) Throw the lever of the TEL key on the talk and signal panel as follows:

(*a*) To talk or monitor toward the opposite terminal of the system, throw the TEL key to LINE OR 2W SWBD.

(*b*) To talk or monitor toward the connected telephone circuit, throw the TEL key to 4W EXT.

(3) Operate the lever on the handset to talk. To monitor, leave the lever unoperated.

d. At Repeater CF–3–A. (1) To monitor on conversation over channel 1 from terminal A, throw the TEL key lever on the talk and signal panel to the A position. Use the handset provided on the repeater. To talk to terminal A, turn the switch on the handset.

(2) To monitor on conversation over channel 1 from terminal B, throw the TEL key lever to the B position. To talk to terminal B, turn the switch on the handset.

86. Adjustment of Test Power at Terminals

The 1,000-cycle test power at each terminal should be adjusted to the proper output as follows:

a. Turn on the 1,000-cycle oscillator by throwing the OSC switch on the measuring panel to the ON position.

b. Turn the six-position switch on the measuring panel to the OSC position and read the meter.

c. After allowing the oscillator tube to reach operating temperature, which is indicated when the meter reading becomes stable, adjust the CAL potentiometer on the measuring panel until the meter reads —4 dbm on the upper scale.

Section V. SYSTEM LINE-UP

87. Over-All System Line-Up for Spiral-Four System

The over-all system line-up given in paragraphs 88 to 94 is for a spiral-four cable system using Telephone Terminals CF–1–A (Carrier) and CF–1–B (Carrier) and Repeaters CF–3–A. If the terminal is used with Carrier Hybrid CF–7 or with Converter CF–4 and Repeater CF–5, see TM 11–2003 or TM 11–2008, respectively. The line-up of a cable system using Telephone Terminals CF–1–B is the same as that used with Telephone Terminals CF–1–A, except that the adjustment of the circuit net loss is different when a four-wire termination is used. Paragraph 92 explains the adjustment of net loss when Telephone Terminals CF–1–B are used.

a. The initial line-up should be made completely. Records should be made of all readings and adjustments for reference in subsequent

line-ups or in tracing system trouble. These line-ups are supervised by the control office, designated terminal A. The repeater stations and terminal B should report all readings to terminal A. The dial settings of the repeaters and the receiving terminal vary with the length and temperature of the cable sections. The settings of the channel GAIN potentiometers at the terminals depend on the circuit net losses specified. The term *circuit net loss* is used to denote the loss between the two-wire side of the hybrid coil at one terminal and the two-wire side of the hybrid coil at the other terminal.

b. The line-up of the system is made by sending test power from each terminal on channels 1, 4, and 2, and by adjusting the equalizer dials at the repeaters and receiving terminal until the desired output is obtained at each test frequency. The test power output at the two-wire line of each channel is then adjusted to obtain the specified circuit net loss. The test power is such that the circuit net loss in decibels is numerically equal to the received test power in dbm; that is, when the test power measured at the two-wire line is −6 dbm the circuit net loss is 6 db. After completing the line-up, a ringing test is made on each channel between switchboards.

c. Adjustments are made and completed at each repeater in turn before proceeding to the next repeater. The receiving terminal is lined up last. Each direction of transmission is lined up independently.

d. A chart is provided on the equalizer panel at both a terminal and a repeater to record the dial settings. The dial settings or the chart record should not be changed except at the direction of the control terminal.

88. Measurement of Output of Transmitting Terminal

The test power output of the transmitting terminal is measured to check the continuity of the transmitting circuit of each channel. These limits apply only when connections are to spiral-four lines. For these measurements the equipment should be terminated in the cable and the OUTPUT key lever should be at the NORMAL position unless the use of the +5-db or the +10-db position has been specified. No adjustment is provided and the test is made as follows:

a. Throw the SEND key levers on the channel 1, channel 2, channel 3, and channel 4 panels to the SEND position.

b. Turn the switch on the measuring panel to position 1 and throw the MEAS key lever to the TRSG position. The meter should read between −1.5 and +1.5 dbm on the lower scale.

c. Turn the six-position switch to position 4. The meter should read between −1.5 and +1.5 dbm on the lower scale.

d. Turn the six-position switch to position 2. The meter should read between −1.5 and +1.5 dbm on the lower scale.

e. Turn the six-position switch to position 3. The meter should read between −1.5 and +1.5 dbm on the lower scale.

f. Remove the a-c power plugs from the outlets, thus transferring to operation on the 12-volt battery supply. The meter reading for the test outlined in *e* above, should be between −1.5 and +1.5 dbm on the lower scale. If this limit is not met, replace the frequency generator (vibrator) G. Reinsert the a-c power plugs.

g. Restore the SEND key lever on the channel 3 panel to normal.

89. Adjustment of Repeater Outputs

a. Adjustment of Output of First Repeater. (1) The repeater is lined up by sending test power from the transmitting terminal on channels 1, 4, and 2 and adjusting the equalizer control dials on the repeater to obtain the specified output. Dial 2 may be adjusted by sending test tone on channel 3 if for some reason channel 2 cannot be used. The repeater output key lever at the repeater should at the NORMAL position with the key guard in place unless the control terminal specifies otherwise.

(2) When lining up in the A to B direction, throw the MEAS key lever on the measuring and binding post panel to the AB position and adjust the dials on the AB equalizer panel as outlined in (4) below.

(3) When lining up in the B to A direction, throw the MEAS key lever on the measuring and binding post panel to the BA position and adjust the dials on the BA equalizer panel as outlined in (4) below.

(4) The dials on the equalizer panels are adjusted as follows and should be adjusted in the order indicated:

(*a*) Check to see that the MILES dial is set in accordance with the distance to the preceding terminal or repeater station. (See par. 82.) The MILES dial on the AB equalizer panel is set for the distance towards A for the A to B direction and on the BA equalizer panel for the distance towards B for the B to A direction. Record the setting of

the MILES dials on the charts on the equalizer panels.

(*b*) Set the measuring and binding post panel switch on position 1 and adjust dial 1 until the meter reads between −1 and +1 dbm on the lower scale. Record the dial setting on the chart.

(*c*) Set the measuring and binding post panel switch on position 4 and adjust dial 4 until the meter reads between −1 and +1 dbm on the lower scale. Record the dial setting on the chart.

(*d*) Set the measuring and binding post panel switch on position 2 and adjust dial 2 until the meter reads between −1 and +1 dbm on the lower scale. Record the dial setting on the chart.

(5) Remove the a-c power plug and note the reading of the meter. The meter should read between −1 and +1 dbm on the lower scale for the test outlined in (*d*) above. If this limit is not met, replace the frequency generator G. Replace the a-c power plug. This test need be made for only one direction of line-up.

b. Adjustment of Output of Succeeding Repeaters. Repeat *a* above at each succeeding repeater in turn.

90. Adjustment of Output of Terminal Receiving Amplifier

The receiving amplifier at the receiving terminal is lined up by sending test power from the transmitting terminal on channels 1, 4, and 2 in the same manner as at the repeaters.

a. Throw the key lever on the measuring panel to the REC position and adjust the dials on the equalizer panel as outlined in paragraph 88*a*(4). The REC–LEV key lever should be in the normal position.

b. If the preceding line section exceeds 45 miles, the meter reading may be below 0 dbm with dial 1 on step 30. In this case, adjust dials 4 and 2 to observe the same reading as that obtained for dial 1. If the meter reading is below −5 dbm, throw the key lever on the channel 1 panel to REC LEV. Reset the key guard.

91. Adjustment of Circuit Net Loss on Telephone Terminal CF–1–A

The circuit net loss of each channel is set after line-up of the system by sending test power from the transmitting terminal and adjusting the channel gain potentiometer at the receiving terminal. Each channel is adjusted individually as follows:

a. Throw the key lever on the channel 3 panel at the transmitting terminal to SEND. (The SEND key levers for channels 1, 2, and 4 have already been operated (par. 88).)

b. At the receiving terminal turn the switch on the measuring panel to the 2W position.

c. Throw the key lever to MEAS position on the channel panel for the channel to be measured and adjust the GAIN potentiometer on that panel until the meter reads within 1 db of the specified circuit net loss, using the upper scale. For example, for a 6-db circuit net loss, the meter should read between −7 and −5 dbm.

d. If a system longer than about 35 miles is operating without repeaters and the specified channel net loss is 6 db, channel 1 may sound hollow or sing. In such cases it will be necessary to reduce the setting of the channel 1 GAIN dial by one or more steps until the hollow or singing condition disappears.

e. After the channel net loss has been adjusted on each channel, throw the SEND key levers to their normal position at the transmitting terminal. Throw the OSC switch to the OFF position.

92. Adjustment of Circuit Net Loss on Telephone Terminal CF–1–B

a. General. The circuit net loss of each channel is adjusted after line-up of the system by sending test power from the transmitting terminal and adjusting the channel GAIN potentiometer at the receiving terminal. Each channel is adjusted individually. While the procedures for channels using two-wire and four-wire terminations are the same, the requirements are different and therefore each case is covered separately. A channel may be terminated on a two-wire basis at one terminal and on a four-wire basis at the other terminal. When adjusting the circuit net loss at the terminal for the channel terminated on a two-wire basis, use the procedure given in *b* below. When adjusting the circuit net loss at a terminal having a channel terminated on a four-wire basis, use the procedure given in *c* below.

b. Channel Terminated on a Two-wire Basis. (1) Throw the key lever on the channel 3 panel at the transmitting terminal to SEND. (The SEND key levers for channels 1, 2, and 4 have already been operated (par. 88).)

(2) At the receiving terminal, turn the switch on the measuring panel to the NET LOSS position. This switch position is the same as 2W on Telephone Terminal CF–1–A.

(3) Throw the key lever on the channel panel for the channel to be measured to the MEAS position, and adjust the GAIN potentiometer on

that panel until the meter reads within 1 db of the specified circuit net loss. Use the upper scale. For example, for a 6-db circuit net loss, the meter should read between −7 and −5 dbm on the upper scale.

(4) After the channel net loss has been adjusted, throw the SEND key lever of the channel in question to its normal position at the transmitting terminal. Throw the OSC switch lever to the OFF position. At the receiving terminal, restore the MEAS key on the channel panel to normal.

c. Channels Terminated on a Four-wire Basis. (1) Throw the key lever on the channel 3 panel at the transmitting terminal to SEND. (The SEND key levers for channels 1, 2, and 4 have already been operated (par. 88).)

(2) At the receiving terminal, turn the switch on the measuring panel to the NET LOSS position.

(3) Throw the key lever to the MEAS position on the channel panel for the channel to be measured, and adjust the GAIN potentiometer on that panel until the upper scale of the meter reads within plus or minus 1 db of the value given in table XI.

The over-all loss between switchboards of any telephone circuit formed of carrier channels connected together on a four-wire basis should be 6 db in the usual case.

Table XI.—Typical circuit net loss requirements

If channel is connected to—	Normal reading (upper scale)
A channel of another spiral-four system terminated on a four-wire basis.	0 dbm.
A four-wire voice-frequency telegraph system.	−6 dbm.
A channel of Carrier Terminal OA–11/FC or OA–12/FC.	−13 dbm, (Estimate. Set slightly to left of −12).
A channel of Carrier Terminal OA–13/FC.	−4 dbm.
Any other type of telephone equipment.	A value to give proper input power to the connected equipment. (See literature accompanying the connected equipment for this value.)

(4) After the channel net loss has been adjusted throw the SEND key levers to their normal position at the transmitting terminal. Throw the OSC switch lever to the OFF position. At the receiving terminal restore the MEAS key on the channel panel to normal.

93. Line-up in Opposite Direction

Line up the systems in the opposite direction using the procedures given in paragraphs 88 to 91 for Telephone Terminal CF–1–A and paragraphs 88 to 90 and paragraph 92 for Telephone Terminal CF–1–B. After line-up is completed in both directions replace the key guards on the SEND and MEAS keys on the channel 3 panel and on the REC LEV and OUTPUT keys on the channel 1 panel.

94. Check of Ringing Over Channels

a. On completion of the system line-up a check should be made of the ringing units associated with each channel by sending a ringing signal between switchboards in each direction.

b. The ringing equipment provides two distance ranges, LOW and HIGH. The LOW range is ordinarily adequate for operation over the carrier channels and should be used since the ringing equipment is less liable to false operation with this setting.

c. Operation of the ringing equipment on the emergency 12-volt battery should be checked by temporarily disconnecting the a-c power plug associated with the ringer and repeating *a* above.

95. Line-up When Telephone Terminal CF–1–A is Arranged for Four-wire Operation

With Telephone Terminal CF–1–A arranged for four-wire operation as shown in figure 53, the operation of the SEND key permits sending the normal amount of 1,000-cycle testing power (−4 dbm) out over the channel and the carrier system. When the MEAS key is operated the received testing power is measured in the normal way. Consequently, when a 3-db pad is provided the channel may be lined up in the regular way for the specified net loss, usually 6 db. When a 6-db pad is provided and the channel is lined up in the normal way, the circuit net loss between binding posts will be 9 db because the pad is connected in the circuit on the extension side of the SEND key and not in the part of the circuit under measurement. When no pad is used the circuit net loss will be 3 db.

96. Line-up Procedure When Channels Are Dropped at Intermediate Points

Line-up procedures when channels are dropped at intermediate points differ depending upon whether two Telephone Terminals CF–1–A or two Telephone Terminals CF–1–B, or one of each, are operated back-to-back.

a. Special Line-up Procedure for Through Channels (Telephone Terminal CF–1–A). (*Through channels without bridging extension.*

these channels, the GAIN potentiometers on both Telephone Terminals CF–1–A at the intermediate point must be increased six steps. This results in a 0-db net loss circuit from each distant terminal and a 6-db net loss circuit to each distant terminal, providing the normal over-all loss of 6 db in both directions of transmission over the complete circuit of two channels in tandem.

(2) *Through channels with bridging extension.* On these channels, the GAIN potentiometers on both Telephone Terminals CF–1–A at the intermediate point must be increased three steps. This compensates for the 3-db net loss introduced into through transmission by the bridged circuit and gives a total loss of 12 db for through transmission in both directions. This also compensates for the 3-db net loss introduced between either distant terminal and the bridging circuit, but not for the additional loss between the bridging circuit and either terminal. Thus the loss from either terminal to the bridging extension is 6 db, and the loss from the bridging extension to either terminal is 9 db.

(3) *Final adjustment.* In the cases given in (1) and (2) above, the final adjustment of through channel net loss may be made by sending on the channel at the transmitting terminal and adjusting the channel GAIN potentiometer at the receiving terminal until the specified net loss is read on the upper scale of the meter at the receiving terminal.

(4) *Limitations.* If the intermediate terminals require more than about 50 feet of wire for connection of unbridged through channels, the two-wire balance of such channels may be so upset that excessive echoes or over-all singing will be encountered when attempting to use the losses indicated in (1) and (2) above. On bridged through channels, the bridging arrangement will also cause additional unbalance. If such effects are encountered, it generally will be possible to use the channels by operating them with lower gain than specified in (1) and (2) above, thus giving circuits with greater net loss.

b. Special Line-up Procedure for Through Channels (Telephone Terminal CF–1–B. (1) *Through channels using adjacent Telephone Terminals CF–1–B or Carrier Terminals OA–11/FC, OA–12/FC, or OA–13/FC.* Connect the channels of the two systems together on a four-wire basis as outlined in paragraph 66. Line up the links. (See pars. 87–94.)

(2) *Through channels using one Telephone Terminal CF–1–A and one Telephone Terminal CF–1–B.* Connect the channels of the two systems together on a two-wire basis. (See pars. 64 to 66.) Line up the channels, using the line-up procedure given in *a* (1) above.

(3) *Through channels with bridging extensions.* When bridging extensions are required, the channels of the two systems must be connected together on a two-wire basis. (See par. 66.) Line up the channels in the same manner as for Telephone Terminals CF–1–A. (See *a* (2) and (3) above.)

Section VI. SUMMARY OF PROCEDURE FOR PLACING EQUIPMENT IN SERVICE

97. Installation of Telephone Terminal CF–1–A

Caution: This equipment may be damaged if connected to a 220- to 250-volt a-c supply before changing internal connections at the terminal strips AC on the PWR SUP panels A and B. Proper connections are given in paragraph 61 and are shown on the circuit labels (figs. 64 and 65) on the inside of the panel covers. Check these. Connect the field telephone set to the TEL binding posts on the signal panel for talking and monitoring.

a. External Connections. (1) Uncouple the cable stub at the connector.

(2) Connect the ground lead, the cable stub, the ringing equipments, and the telegraph terminal and simplex telegraph circuit, if used, at the binding post panel in accordance with the system diagram on the inside of the cabinet front cover. (See fig. 79.)

(3) Recouple the cable stub.

b. Dial Settings. (1) Set the dials on the equalizer panel to positions indicated on the equalizer chart.

(2) Set all GAIN dials to step 21.

c. Key Settings. (1) See that all key levers are normal.

(2) In order to throw a key lever with a guard, unscrew the lever handle, remove the guard, and throw the lever to the desired position.

(3) Replace the guard.

d. Power Connections. (1) Connect the battery cord of the PWR SUP B panel. Insure the correct polarity of the battery connections. The power vibrator should start.

(2) Connect the battery cord of the PWR SUP A panel. The calling-in bell should ring.

(3) Throw the SIGNAL CUTOFF key lever.

(4) See that the a-c plugs of both power supply panels are connected to outlets on the floor; then

connect the long a-c cord from the outlet box to the a-c supply. Both power vibrators should stop.

e. SIGNALING. (1) Connect the signaling circuit at the binding posts as shown in the system diagram. (See fig. 79.)

(2) At terminal B throw the BATTERY-GROUND key lever on the SIG panel to the GROUND position.

(3) At terminal A leave this key in its normal (BATTERY) position.

(4) When installation is complete at all stations, the signaling simplex is closed through and the bell again rings.

(5) Restore the SIGNAL CUTOFF key lever.

Note.—Terminals should challenge frequently to contact other stations in case the signaling circuit does not operate properly.

f. CHECK OF TRANSMITTING CIRCUIT. This check is made to insure that the equipment is in working order. No adjustments are provided. The cable must be connected and in good condition. These limits apply only when connections are made to spiral-four lines.

(1) Calibrate for sending. See instructions on sending 1,000-cycle test tone. (See par. 98*b* and *c*.)

(2) Set the rotary switch dial on the measuring panel and throw the SEND key levers on the channel panels as indicated in table XII. For each position of the rotary switch, throw the key lever on the measuring panel to TRSG and read the meter.

Table XII.—Dial and key settings for check of transmitting circuit, Telephone Terminal CF–1–A

Turn rotary switch on measuring panel to—	Throw SEND key lever on—	Meter reading, lower scale
Position 1	CHAN 1 panel	Between +1.5 and −1.5 dbm.
Position 4	CHAN 4 panel	Between +1.5 and −1.5 dbm.
Position 2	CHAN 2 panel	Between +1.5 and −1.5 dbm.
Position 3	CHAN 3 panel	Between +1.5 and −1.5 dbm.
Position 3*	CHAN 3 panel	Between +1.5 and −1.5 dbm.

*The last test is made with the a-c supply disconnected to check operation on reserve batteries.

(3) When installation is complete at all stations, the control terminal takes charge of lining up the circuit in each direction. The terminals adjust the new loss of each channel and make operating tests of the ringing equipment.

98. Operation of Telephone Terminal CF–1–A

a. COMMUNICATION. (1) Throw the MON key lever on the channel panel to monitor on that channel. Throw the TALK key lever to talk.

(2) Throw the SIGNAL key lever on the signal panel for 2 seconds for each ring to call other stations in accordance with the prearranged signaling code set up for the system.

(3) Use channel 1 for talking to other stations since the repeater operator can talk only on channel 1.

(4) The TALK key levers should be in their normal position when not in use.

b. TO SEND 1,000-CYCLE TEST TONE. (1) Throw the OSC switch to ON. Allow 2 minutes for the tube to heat.

(2) Set the rotary switch dial on the measuring panel to OSC.

(3) Turn the CAL knob until the meter reads −4 on the upper scale.

(4) Throw the SEND key lever on the channel panel of the channel on which it is desired to send.

(5) Keep the OSC switch in its OFF position when the oscillator is not in use.

c. OUTPUT. For systems without intermediate repeaters, throw the OUTPUT key lever on the channel 1 panel as shown in table XIII.

Table XIII.—Position of output key lever for systems without intermediate repeaters, Telephone Terminal CF–1–A

Distance between terminals	Position of OUTPUT key lever
Less than 30 miles	NORMAL
30 to 37.5 miles	+5DB
37.5 to 45 miles	+10DB

For systems with repeaters, the OUTPUT and REC LEV key levers should be at their normal positions unless it is necessary to operate with abnormal output because of unusual conditions. The control terminal must instruct other stations affected if an OUTPUT key lever position other than NORMAL is rquired.

d. TO LINE UP CIRCUIT. (1) Terminal A sends to line up in AB direction.

(2) The repeater adjacent to terminal A adjusts dials on the equalizer panel AB first, the second repeater adjusts the dials on the equalizer panel AB, etc.

(3) Terminal B adjusts the dials on the equalizer panel last.

(4) Terminal B sends to line up in the BA direction.

(5) The repeater adjacent to terminal B adjusts the dials on the equalizer panel BA first, the next repeater adjusts the dials on the equalizer panel BA, etc.

(6) Terminal A adjusts the dials on the equalizer panel last.

(7) Terminals measure at the output of the REC amplifier when adjusting dials on the equalizer panel.

(8) At each station channels are adjusted in the order given in table XIV. All stations adjust for meter readings of between +1 and −1 unless the control terminal instructs otherwise. The net losses of each channel are adjusted after lining up.

Table XIV.—Dial settings for line-up of circuit, Telephone Terminal CF–1–A

With terminal sending on—	Turn rotary switch dial on measuring panel to—	Adjustment made on equalizer panel	Meter reading, lower scale
Channel 1	Position 1	Dial 1	Between +1 and −1 dbm.
Channel 4	Position 4	Dial 4	Between +1 and −1 dbm.
Channel 2	Position 2	Dial 2	Between +1 and −1 dbm.

(9) All stations record final dial settings on the equalizer charts as authorized settings.

e. To Measure at Output of REC Amplifier. (1) Set the rotary switch dial on the measuring panel to the position corresponding to the channel number on which the distant end is sending.

(2) Throw the key lever on the measuring panel to REC.

(3) Read the meter on the lower scale.

f. To Measure Circuit Net Loss. (1) Set the rotary switch dial to 2W.

(2) Throw the MEAS key lever of the channel on which the distant end is sending. Read the meter on the *upper scale.*

(3) Net loss is adjusted by the GAIN dial on the channel panel.

99. Installation of Telephone Terminal CF–1–B

Caution: This equipment may be damaged if connected to a 220- to 250-volt a-c supply before changing internal connections at the terminal strips AC on PWR SUP panels A and B. Connect leads to the top row of terminals according to paragraph 61 and to note 5 on the circuit label (fig. 65) on the inside of the panel covers according to the power supply line voltage available.

a. External Connections. (1) Uncouple the cable stub at the connector.

(2) Connect the GRD binding post on the right-hand end of the PWR SUP panel B.

(3) Connect the cable stub, the ringing equipments, the telegraph terminal or other telephone equipment, and the simplex telegraph circuit, if one is used, at the binding post panel in accordance with the system diagram on the inside of the cabinet front cover. (See fig. 80.)

(4) Use CHANNELS–2W OR 4W TRANSMITTING binding posts for channels terminated two-wire and for the transmitting side of channels terminated four-wire.

(5) Use CHANNELS–4W RECEIVING binding posts only when the receiving side of channels are terminated four-wire. See figures A and B on the system diagram (fig. 80) for four-wire connections and the use of 4-db pads.

(6) Recouple the cable stub.

b. Dial Settings. (1) Set the dials of the equalizer panel to positions indicated on the equalizer chart.

(2) When Telephone Terminal CF–1–B is used in conjunction with Converter CF–4, set the equalizer dials according to instructions for Converter CF–4.

(3) Set all GAIN dials to step 21.

c. Key Settings. (1) On the talk and signal panel operate the key levers of the CHANNEL TERMINATION keys to 4 WIRE for channels terminated four-wire.

(2) See that all other keys on the talk and signal panel and all the keys on other panels are normal.

(3) In order to operate a key lever with a guard, unscrew the lever handle, remove the guard, and operate the lever to the desired position.

(4) Replace the guard and lever handle.

d. Power Connections. (1) Connect the battery cord of the PWR SUP B panel. Insure the correct polarity of the battery connection. The power vibrator should start.

(2) Connect the battery cord of the PWR SUP A panel. The calling-in bell should ring.

(3) Operate the SIGNAL CUTOFF key lever.

(4) See that the a-c cords of both power supply panels are connected to the outlets on the floor, then connect the long a-c cord from the outlet box to the a-c supply. Both power vibrators should stop.

e. Signaling. (1) Connect the signaling circuit at the binding posts as shown in the system diagram. (See fig. 80.)

(2) At terminal B operate the BATTERY-GROUND key lever on the talk and signal panel to the GROUND position.

(3) At terminal A leave the BATTERY-GROUND key in its normal (BATTERY) position.

(4) When installation is complete at all stations, the signaling simplex is closed through and the bell again rings.

(5) Restore the SIGNAL CUTOFF key lever.

Note.—Terminals should challenge frequently to contact other stations in case the signaling circuit does not operate properly. When Telephone Terminal CF–1–B is used with Converter CF–4, see TM 11–2008.

f. Check of Transmitting Circuit. This check is made to insure that the equipment is in working order. No adjustments are provided. The cable must be connected and in good condition. These limits apply only when connections are made to spiral-four lines.

(1) Calibrate for sending. See instructions on sending 1,000-cycle test tone. (See par. 100*c* and *d*.)

(2) Set the rotary switch dial on the measuring panel and operate the SEND key levers on the channel panels as indicated in table XV. For each position of the rotary switch, operate the key lever on the measuring panel to TRSG and read the meter.

Table XV.—Dial and key settings for check of transmitting circuit, Telephone Terminal CF–1–B

Turn rotary switch on measuring panel to—	Operate SEND key lever on—	Meter reading, lower scale
Position 1	CHAN 1 panel	Between +1.5 and −1.5 dbm.
Position 4	CHAN 4 panel	Between +1.5 and −1.5 dbm.
Position 2	CHAN 2 panel	Between +1.5 and −1.5 dbm.
Position 3	CHAN 3 panel	Between +1.5 and −1.5 dbm.
Position 3*	CHAN 3 panel	Between +1.5 and −1.5 dbm.

*The last test is made with the a-c supply disconnected to check operation on reserve batteries.

(3) When installation is complete at all stations, the control terminal takes charge of lining up the circuit in each direction. The terminals adjust the net loss of each channel and make operating tests of the ringing equipment.

100. Operation of Telephone Terminal CF–1–B

a. To Talk and Monitor. (1) Operate the TALK-MON key lever to MON. To talk, operate the key lever to TALK. Then press switch on the handset to talk.

(2) Place the TEL key on the talk and signal panel in normal position to talk on a channel terminated two-wire and toward the line on a channel terminated four-wire.

(3) Operate the TEL key lever to 4 WIRE EX to talk toward a connected circuit on a channel terminated four-wire.

(4) Use channel 1 for talking to other stations since repeater operators can talk only on channel 1.

(5) When they are not in use, TALK key levers should be at normal position.

b. To Signal. Operate SIGNAL key lever on talk and signal panel for 2 seconds for each ring to call other stations in accordance with the prearranged code set up for the system.

c. To Send 1,000-cycle Test Tone. (1) Throw the OSC switch to ON. Allow 2 minutes for the tube to heat.

(2) Set the rotary switch dial on the measuring panel to OSC.

(3) Turn the CAL knob until the meter reads −4 on the upper scale.

(4) Operate the SEND key lever on the channel panel on which it is desired to send.

(5) Keep the OSC switch in its OFF position when the oscillator is not in use.

d. Output. For cable systems without intermediate repeaters operate OUTPUT key lever on channel 1 panel as given in table XVI. For cable systems with repeaters, OUTPUT and REC LEV key levers should be normal unless necessary to operate abnormal output because of unusual conditions. Control terminal must instruct other stations affected if OUTPUT key lever position other than NORMAL is required. When this equipment is being used with Converter CF–4, operate the OUTPUT key lever to normal.

Table XVI.—Position of output key lever for systems without intermediate repeaters, Telephone Terminal CF–1–B

Distance between terminals	Position of OUTPUT key lever
Less than 30 miles	NORMAL
30 to 37.5 miles	+5db
37.5 to 45 miles	+10db

e. To Line Up Circuit. (1) Terminal A sends to line up in AB direction.

(2) Repeater adjacent to A adjusts dials on equalizer panel AB first.

(3) Second repeater adjust equalizer panel AB etc.

(4) Terminal B adjusts dials on equalizer panel last.

(5) Terminal B sends to line up in BA direction.

(6) Repeater adjacent to B adjusts dials on equalizer panel BA first; then next repeater, etc.

(7) Terminal A adjusts dials on equalizer panel last.

(8) Terminals measure at output of REC amplifier when adjusting dials on equalizer panel.

(9) At each station channels are adjusted in the order given in table XVII.

Table XVII.—Dial settings for line-up of circuit, Telephone Terminal CF–1–B

With terminal sending on—	Turns rotary switch dial on measuring panel to—	Adjustment made on equalizer panel	Meter reading lower scale
Channel 1	Position 1	Dial 1	Between +1 and −1 dbm.
Channel 4	Position 4	Dial 4	Between +1 and −1 dbm.
Channel 2	Position 2	Dial 2	Between +1 and −1 dbm.

(10) All stations adjust for meter readings of between +1 and −1 unless control terminal instructs otherwise. Net losses of each channel are adjusted after lining up.

(11) All stations record final dial settings on equalizer charts as authorized settings.

f. To Measure at Output of REC Amplifier. (1) Set rotary switch dial on measuring panel to the position corresponding to channel number on which distant end is sending.

(2) Throw key lever on the measuring panel to REC.

(3) Read meter on the lower scale.

g. To Measure Circuit Net Loss. (1) Set the rotary switch dial on measuring panel to NET LOSS.

(2) Throw MEAS key lever of channel on which the distant end is sending. Read the meter on *upper scale*.

Table XVIII.—Net loss obtained by adjustment of gain dial

Channel termination	Normal net loss (db)
Two-wire, 6-db circuit	Between −5 and −7.
Four-wire, connected to another Telephone Terminal CF–1–B terminated four-wire.	Between +1 and −1.
Four-wire, connected to voice-frequency telegraph terminal on four-wire basis.	Between −5 and −7.
Four-wire, connected to other type of four-wire circuit.	See text of the Technical Manual covering the connected equipment.

(3) Net loss is adjusted by the GAIN dial on the channel panel.

(4) Adjust GAIN dial to give the net loss given in table XVIII.

101. Installation and Operation Repeater CF–3–A

Caution: Check for 115- or 230-volt wiring on the power supply panel. See paragraph 61 or the label on the inside of the panel cover. (See figs. 64 and 65.)

a. Installation. (1) Uncouple the cable stubs at the connectors.

(2) Connect the cable stubs, ground lead, signaling, and telegraph at the binding posts as shown on the schematic diagram. (See fig. 92 or 94.)

(3) Connect the battery. Note that the bell rings.

(4) Throw the SIGNAL CUTOFF key.

(5) Connect the a-c supply. Note that the vibrator stops.

(6) Set the equalizer dials to positions indicated on the equalizer chart.

(7) Recouple the cable stubs.

(8) Monitor in both directions and answer when the terminal challenges.

(9) When installation is complete at all stations, the bell will ring. Then restore the SIGNAL CUTOFF key.

b. Communication. (1) Throw the TEL key lever to A to monitor in the AB direction or to talk to terminal A.

(2) Throw the TEL key lever to B to monitor in the BA direction or to talk to terminal B.

(3) Turn the switch on the headset to talk. A continuous signal indicates a cable break.

(4) Monitor on A and B until the terminal challenges.

(5) Throw the SIGNAL key lever for 2 seconds for each ring to call other stations in accordance with the prearranged signaling code set up for the system.

c. Line-up. (1) See that the OUTPUT key lever is in its normal position unless the control terminal requests a +5- or +10-db position.

(2) Throw the MEAS key lever to the AB position and adjust the dials of the equalizer panel AB for line-up in the AB direction.

(3) Throw the MEAS key lever to BA and adjust the dials of the equalizer panel BA for line-up in the BA direction.

(4) Adjust for a meter reading between +1 and −1 unless the control terminal instructs otherwise.

These limits apply only when connections are made to spiral-four lines.

(5) The control terminal supervises the line-up and the channels are adjusted in the order given in table XIX.

Table XIX.—Dial settings for line-up of Repeater CF–3–A

With terminal sending on—	Turns rotary switch dial on measuring panel to—	Adjustment made on equalizer panel	Meter reading, lower scale
Channel 1	Position 1	Dial 1	Between +1 and −1 dbm.
Channel 4	Position 4	Dial 4	Between +1 and −1 dbm.
Channel 2	Position 2	Dial 2	Between +1 and −1 dbm.
Channel 3	Position 3	Dial 3	Between +1 and −1 dbm.

(6) Record final dial settings on the equalizer charts.

Section VII. ROUTINE CHECKS OF PERFORMANCE

102. Records

a. Each station should maintain a record showing when periodic tests or line-ups are made, the settings of the various dials and switches, and the troubles found and when and how they are cleared. These records, properly kept, will indicate which equipment and circuits need most attention. It may also be useful in locating conditions causing circuit failures.

b. Forms for recording such data may be made to cover transmission in both directions, results of over-all system line-up tests, and operating adjustments. These forms may be designed to cover the results for a single day or for several days if experience indicates that the number permits such usage.

103. Purpose and Use of Check List

a. General. The equipment performance check lists (pars. 104 and 105) will help the operator determine whether Telephone Terminal CF–1–A or CF–1–B or Repeater CF–3–A are functioning properly. The check list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures that the operator can take. Items 1 to 9 for Telegraph Terminal CF–1–(*) and 1 to 8 for Repeater CF–3–A correspond to the equipment connections and initial adjustments before operation. Items 10 to 26 for Telegraph Terminal CF–1–(*) and 9 to 15 for Repeater CF–3–A correspond to the initial line-up and are checked when the system is about to go into operation after having been shut down. Items 27 to 42 for Telephone Terminal CF–1–(*) and 16 to 19 for Repeater CF–3–A correspond to the daily measurements which are made during operation.

b. Action or Condition. For some items the information given in the action or condition column consists of the settings of various switches and controls under which the item is to be checked. For other items it represents an action that must be taken in order to check the normal indication given in the normal indication column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator will find when he checks the items. In meter readings, the allowable tolerances of the readings are given. When a meter reads within the limits specified, operation may be considered satisfactory. A meter reading outside the limits given is a sign of impending trouble. If the indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those that the operator can make without turning in the equipment for repairs. A reference to part five indicates that the correction of the trouble cannot be effected during operation and that trouble shooting by an experienced repairman is necessary. If the set is completely inoperative or if the recommended corrective measures do not yield results, trouble shooting is necessary. However, if the tactical situation requires that communication be maintained and if the set is not completely inoperative, the operator must maintain the set in operation as long as it is possible to do so.

104. Equipment Performance Check List for Telephone Terminal CF–1–(*)

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1	PWR SUP B battery cord.	Connected to 12-volt battery.		
	2	PWR SUP A battery cord.	Connected to 12-volt battery.		
	3	A-c cord	A-c plugs from both power supply panels connected to outlets in floor.		
	4	BATTERY-GROUND key on talk and signal panel.	Operate to GROUND		
	5	Cable Stub CC–356	Connect white pair to TRSG binding posts. Connect colored pair to REC binding posts. Connect shield lead to SH binding post.		
	6	SX binding posts (terminal A).	Connect SX–TRSG binding post to SIG binding post. Connect SX–REC binding post to telegraph equipment on simplex circuit.		
	7	SX binding posts (terminal B).	Connect SX–REC binding post to SIG binding post. Connect SX–TRSG binding post to telegraph equipment on simplex circuit.		
	8	EQL panel	MILES, 1, 4, and 2 dials set according to chart on equalizer panel.		
	9	GAIN potentiometer (all channels).	Set according to circuit net losses specified.		
START	10	OSC switch	Operate to ON position	Meter reading (upper scale) −4 dbm.	Adjust CAL knob.
	11	Measuring panel selector switch.	Turn to OSC position		
	12	SEND key (all channels)	Operate		
	13	Measuring panel key	Operate to TRSG position		
	14	Measuring panel selector switch.	Turn to— 1 4 2 3	Meter reading (lower scale): 0±1.5 dbm. 0±1.5 dbm. 0±1.5 dbm. 0±1.5 dbm.	See part 5, pars. 154 and 155.
	15	A-c power plugs	Remove from outlets	Meter reading (lower scale) 0±1.5 dbm.	Replace frequency generator.
	16	A-c power plugs	Reinsert in outlets		
	17	SEND key (all channels)	Restore to normal		
	18	OSC switch	Restore to OFF position		
	19	Measuring panel key	Operate to REC position. Test power from distant terminal on channels 1, 4, and 3.		
	20	REC-LEV key	Normal		
	21	Measuring panel selector switch.	Turn to— 1 4 2	Meter reading (lower scale): 0±1 dbm. 0±1 dbm. 0±1 dbm.	Adjust EQL panel dial: 1. 4. 2.
	22	Measuring panel selector switch.	Turn to 2W		
	23	Channel 1 panel MEAS switch.	Operate	Meter reading (upper scale) specified net loss ±1 db.	Adjust channel 1 panel GAIN potentiometer.
	24	Channel 2 panel MEAS switch.	Operate	Meter reading (upper scale) specified net loss ±1 db.	Adjust channel 2 panel GAIN potentiometer.
	25	Channel 3 panel MEAS switch.	Operate	Meter reading (upper scale) specified net loss ±1 db.	Adjust channel 3 panel GAIN potentiometer.
	26	Channel 4 panel MEAS switch.	Operate	Meter reading (upper scale) specified net loss ±1 db.	Adjust channel 4 panel GAIN potentiometer.

104. Equipment Performance Check List for Telephone Terminal CF–1–(*)—Continued

	Item No.	Item	Action or condition	Normal indication	Corrective measures
EQUIPMENT PERFORMANCE	27	OSC switch	Operate		
	28	Measuring panel selector switch.	Turn to OSC position	Meter reading (upper scale) −4 db.	Adjust CAL knob.
	29	Channel 1 panel SEND key.	Operate		
	30	Measuring panel key	Operate to TRSG position		
	31	Measuring panel selector switch.	Turn to 1	Meter reading (lower scale) 0±1.5 dbm.	See part 5, pars. 154 and 155.
	32	Channel 1 panel SEND key.	Restore to normal		
	33	Channel 4 panel SEND key.	Operate		
	34	Measuring panel selector switch.	Turn to 4	Meter reading (lower scale) 0±1.5 dbm.	See part 5, pars. 154 and 155.
	35	Channel 4 panel SEND key.	Restore to normal		
	36	Channel 2 panel SEND key.	Operate		
	37	Measuring panel selector switch.	Turn to 2	Meter reading (lower scale) 0±1.5 dbm.	See part 5, pars. 154 and 155.
	38	Channel 2 panel SEND key.	Restore to normal		
	39	Channel 3 panel SEND key.	Operate		
	40	Measuring panel selector switch.	Turn to 3	Meter reading (lower scale) 0±1.5 dbm.	See part 5, pars. 154 and 155.
	41	Channel 3 panel SEND key.	Restore to normal		
	42	OSC switch	Restore to OFF position		

Note.—No STOP check required for this equipment.

105. Equipment Performance Check List for Repeater CF–3–A

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1	PWR SUP battery cord	Connect to 12-volt battery.		
	2	A-c cord	A-c plug from PWR SUP panel connected to outlets in floor. A-c cord from outlet connected to a-c supply.		
	3	SX binding posts	Connect SX BA IN binding post to SA binding post. Connect SX AB OUT binding post to SB binding post.		
	4	SX binding posts (no telegraph equipment provided).	Connect SX BA OUT binding post to SX BA IN binding post.		
	5	Cable Stub CC–356 (first).	Connect white pair to BA OUT binding post. Connect colored pair to AB IN binding post. Couple cable Stub toward terminal A.		
	6	Cable Stub CC–356 (second).	Connect white pair to AB OUT binding post. Connect colored pair to BA IN binding post. Couple cable stub toward terminal B.		
	7	Equalizer panel AB	MILES, 1, 4, and 2 dials set in accordance with chart on equalizer panel AB.		
	8	Equalizer panel BA	MILES, 1, 4, and 2 dials set in accordance with chart on equalizer panel BA.		

105. Equipment Performance Check List for Repeater CF–3–A—Continued

	Item No.	Item	Action or condition	Normal indication	Corrective measures
START	9	MEAS key	Operate to AB position while terminal A sends test tone on all channels.		
	10	Measuring panel selector switch.	Turn to—	Meter reading:	
			1	0±1.5 dbm.	
			4	0±1.5 dbm.	
			2	0±1.5 dbm.	
			3	0±1.5 dbm.	
	11	MEAS key	Operate to BA position while terminal B sends test tone on all channels.		
	12	Measuring panel selector switch.	Turn to—	Meter reading:	
			1	0±1.5 dbm.	
			4	0±1.5 dbm.	
			2	0±1.5 dbm.	
			3	0±1.5 dbm.	
	13	Equalizer panel AB	Set MILES dial in accordance with distance to preceding carrier station.		
	14	Equalizer panel BA	Set MILES dial in accordance with distance to preceding carrier station.		
	15	A-c power plugs	Remove from outlets	Meter reading of 0±1.5 dbm.	
EQUIPMENT PERFORMANCE	16	Measuring panel key	Operate to AB position		
	17	Measuring panel selector switch.	Turn to—	Meter reading:	
			1	0±1.5 dbm.	
			4	0±1.5 dbm.	
			2	0±1.5 dbm.	
			3	0±1.5 dbm.	
	18	MEAS panel key	Operate to BA position		
	19	MEAS panel selector switch.	Turn to—	Meter reading:	
			1	0±1.5 dbm.	
			4	0±1.5 dbm.	
			2	0±1.5 dbm.	
			3	0±1.5 dbm.	

Note.—No STOP check required for this equipment.

Table XX.—Typical testing schedule

Test item	Make tests					Remarks
	Initial	Daily	Weekly	Monthly	Other	
Telephone system						
1. Equalization	x	x			x	Daily, 2 hours after sunrise; also when temperature changes widely (see pars. 88 to 90.)
2. Channels 1, 2, and 4, net loss	x	x			x	Also channel 3 initially and when available. (See pars. 91 and 92.)
3. Channels 1, 2, and 4, ringing	x	x			x	Also channel 3 initially and when available; also after lightning storms. (See par. 94.)
4. Channels 1, 2, and 4, talking and listening.	x	x			x	Also channel 3 when used for telephone; test after lightning storms. (See pars. 98 and 100.)
5. Signaling of maintenance circuit	x	x			x	Signal in connection with test 1. (See par. 101*b*.)
6. Equalizer setting	x		x		x	Check for deviation from recorded settings in initial line-up.
7. Synchronism	x				x	Check when poor quality is noted. (See par. 169.)
Equipment tests						
8. Protectors	x		x		x	Clean and check for broken or damaged protectors; also after electrical storms.
9. Fuses	x				x	When equipment fails.
10. Vacuum tubes	x			x	x	When channels fail or system fails; send to depot monthly for complete check. (See par. 76.)
11. Battery fall-back operation	x		x			Routine check of transfer relay. (See par. 78.)
12. Cleaning					x	Keep equipment clean; clean carefully as conditions require; keep covers on relays.

Table XX.—Typical testing schedule—Continued

Test item	Make tests					Remarks
	Initial	Daily	Weekly	Monthly	Other	
Accessory equipment						
13. Battery voltage	x		x		x	Measure when in partial or full-time use as required, otherwise weekly. (See par. 77.)
14. Battery specific gravity and electrolyte level.	x		x		x	Measure when in partial or full time use as required, otherwise weekly. Recharge if specific gravity is 1.240 or less. (See pars. 177 and 178.)
15. Battery charging			x		x	Charge whenever voltage drops below 1.9 volts per cell; 11.5 for 12-volt batteries. (See pars. 177 and 178.)
16. Power unit fueling					x	Every few hours of use. (See TM 11–900, TM 11–914, and TM 11–945.)
17. Power unit oiling			x		x	Or about every 100 hours of running. Follow Technical Manual. (See TM 11–900, TM 11–914, and TM 11–945.)
18. Telephone EE–8–(*)	x			x		Check battery voltage and talking and ringing as part of telephone system test items. (See TM 11–333.)
Line conductors						
19. Resistance and opens	x		x		x	Also when noise is excessive, after lightning storms, or when equalizer dials are several steps from usual settings.
20. Grounds and insulation	x		x		x	

Section VIII. OPERATION UNDER UNUSUAL CONDITIONS

106. Simplified Line-up

To minimize the number of channels out of service at any one time, the procedure outlined below may be followed. The same procedure is followed for each direction of transmission. Adjust the test power at the start of each line-up.

a. Monitor on channel 1 at the terminal to determine that it is idle and proceed as follows:

(1) Send test power on this channel.

(2) Measure test power at output of the transmitting amplifier at the terminal.

(3) Measure test power at the first repeater and adjust dial 1 to obtain an output within −1 dbm and +1 dbm.

(4) Repeat procedure given in (3) above, at each repeater in succession and at the output of receiving amplifier at the receiving terminal.

(5) Measure test power at the two-wire output of this channel at the distant terminal and adjust GAIN potentiometer until it is within ±1 db of specified output.

(6) Remove test power from the channel.

b. Monitor on channel 4 to determine that it is idle, and repeat steps in (1) to (6) above, making adjustments on dial 4 only.

c. Monitor on channel 2 to determine that it is idle, and repeat steps in (1) to (6) above, making adjustments on dial 2 only.

d. If a release can be obtained on channel 3, which is normally assigned to a voice-frequency telegraph, repeat steps in (1), (2), (5), and (6) above, on this channel.

e. At each point, record on the chart the settings obtained in the line-up.

107. Emergency Operation

Paragraphs 108 to 111 describe temporary expedients for maintaining some degree of service over the carrier system in case of emergencies involving:

a. Operation with excessive system noise.

b. Loss of a repeater.

c. Loss of a terminal.

d. Failure of both regular and emergency power at a terminal or at a repeater.

108. Excessive System Noise

As an emergency measure pending the clearance of trouble causing excessive noise, some improvement might be effected by operating the system so that the output power at the terminals and at the repeaters is greater than normal. Operating with increased output power increases the signal-to-noise ratio over the system and may possibly improve transmission under these conditions. When noise is encountered, and before making adjustments, tests should be made to determine the cause. A check of the line-up of the system may disclose erroneous gain settings or other reasons for the excessive noise. Adjustments to increase the output power may be made as follows with the later type systems described in paragraph 36*a*.

a. At terminal A, throw the output key lever to the +5DB position.

b. Throw the key levers to SEND at terminal A on channels 1, 2, and 4.

c. At terminal B, adjust the equalizer for normal output on channels 1, 4, and 2.

d. At terminal B, measure and adjust the GAIN potentiometers of channels 1, 2, and 4 for normal output of −6 dbm.

e. Return SEND key levers at terminal A to normal position.

f. Repeat steps *a* to *d* in the B–A directions.

g. If the above steps do not sufficiently reduce the effect of the noise, throw the OUTPUT key lever at terminal A to the +10DB position and repeat steps *b* to *e*.

h. Restore the SEND key levers to their normal positions.

i. The control terminals should advise the repeater stations to throw the OUTPUT key lever on the repeaters to the +5DB or +10DB positions while the system is operating at the higher output condition.

j. If the above procedure does not sufficiently reduce the effect of the noise, additional advantage may sometimes be obtained by reducing the dial settings of the GAIN potentiometers on the channel panels a few steps but do not reduce the GAIN settings more than five steps from the settings obtained in *d* above.

k. Telephone Repeater EE–99–A may be used as a substitute for Repeater CF–3–A, and as a four-wire repeater on cable facilities. However, substitution of Telephone Repeater EE–99–A for Repeater CF–3–A is strictly an emergency measure to be used in case of the break-down of a repeater in use or when Repeater CF–3–A is not available. When Telephone Repeater EE–99–A is used in place of the carrier repeater, modification of the A and B amplifiers, by opening capacitor C9A and capacitor C9B in their respective amplifiers, will improve the repeater action toward high-frequency response. Care must be taken in opening the circuit to be sure that the capacitors are opened on the tube-pin side, and that resistors R21A and R21B remain undisturbed in their respective circuits. No modification is necessary to use the repeater as a four-wire repeater on small cable facilities.

109. Operation With a Missing Repeater

a. If for some reason a repeater becomes inoperative, it may be possible, under favorable circumstances, to operate temporarily with the repeater omitted. The possibility of operating a system with a missing repeater, which is equivalent to operation with an abnormally long repeater span, depends upon the gain margin which is available in the remaining repeaters and the increase in noise which can be tolerated. If the terminals are equipped with OUTPUT keys, somewhat better performance can be obtained by using additional output from the transmitting terminals. If OUTPUT keys are not provided (as is the case in earlier models), the gain in the missing repeater must be compensated for by using additional gain from the remaining repeaters. The gain and noise margins depend upon the spacing of the carrier stations, the temperature of the cable, and the amount of noise due to external interference, such as static which exists at the time.

b. The procedure which will be followed, in order to operate with a repeater missing and with OUTPUT keys provided, is outlined below. It is assumed that the cable has been connected through at the point where the repeater is missing.

(1) In the A to B direction of transmission, throw the SEND key levers at terminal A to send test power on channels 1, 2, and 4.

(2) Throw the OUTPUT key lever at terminal A to the +10DB position.

(3) At the repeaters preceding the section from which the repeater is missing, throw the OUTPUT key levers to the +10DB position.

(4) Adjust dial 1 of the AB equalizer panel at the first repeater, receiving from the long section from which the repeater is missing until an output of 0 dbm is obtained. If normal output is obtained, adjust dials 4 and 2 to obtain normal outputs of 0 dbm on channels 4 and 2. If sufficient output cannot be obtained, set dial 1 on step 30, dial 4 on step 8, and dial 2 on step 4.

(5) At the following repeater adjust dial 1 on the AB equalizer panel to obtain a normal output of 0 dbm on channel 1. If normal output is obtained, adjust dials 4 and 2 to obtain normal outputs of 0 dbm on channels 4 and 2. If normal output cannot be obtained, set dial 1 on step 30, dial 4 on step 8, and dial 2 on step 4.

(6) Repeat (5) above at subsequent repeaters.

(7) Measure the output of the receiving amplifier at the receiving terminal and readjust dials 1, 4, and 2 to obtain a normal output of 0 dbm. If an output of between 0 and −5 dbm cannot be obtained, set dial 1 on step 30, dial 4 on step 8, dial 2 on step 4, and throw the REC LEV key lever.

(8) Measure the net loss of each channel and

adjust the GAIN potentiometers to obtain a net loss of not less than 6 db (−6 dbm).

(9) In the B to A direction of transmission, repeat (1) through (8) above, in the B to A direction of transmission, making adjustments on the BA equalizer panels.

(10) Note that each repeater amplifier transmitting into the long section from which the repeater is missing is adjusted so that the output is +10 dbm. Likewise, the receiving amplifier for the long section is adjusted for normal output of 0 dbm. Consequently, when measuring the repeater output toward the long section the OUTPUT key lever on the measuring panel should be thrown to the +10DB position, and when measuring the output receiving from the long section the OUTPUT key lever should be thrown to the NORMAL position.

(11) If terminal A is not equipped with an output key, the procedure is as follows:

(*a*) Repeat the procedure outlined in (1) above.

(*b*) Adjust dial 1 on the AB equalizer panel of the repeater transmitting into the long section to obtain an output power of +5 dbm (5 db above normal). If sufficient output cannot be obtained, set dial 1 on step 30 and readjust dial 1 on the AB equalizer panel of the preceding repeater until the above requirement can be met. If a +5-dbm output cannot be obtained, use the maximum output available.

(*c*) Adjust dials 4 and 2 on the AB equalizer panel of the repeater transmitting into the long section to obtain an output of +5 dbm.

(*d*) Proceed as outlined in (3) through (8) above.

(*e*) If terminal B is not equipped with an OUTPUT key, proceed with the line-up in the B to A direction of transmission as outlined in (*a*) to (*d*) above.

(*f*) Talk over each channel. If the noise is so great as to make communication difficult, it will sometimes be helpful to readjust the GAIN potentiometers on the individual channels by a few steps in a direction to increase the circuit net loss. Decrease the dial setting. If trouble is experienced in obtaining satisfactory telegraph transmission, operation over another channel should be tried.

110. Operation With a Missing Terminal

In case of the loss of one terminal of a system it is possible to terminate the voice channel at the terminal or at a repeater point and obtain one circuit. In this way, service on channel 1 can be reestablished over part or all of the distance with some increase in the over-all net loss from that normally obtained. Two cases are covered as follows: Where the circuit is to be terminated at a repeater preceding the point of failure and extended for a short distance by a two-wire connection, and where the circuit is to be terminated by connecting to the spiral-four cable at a point beyond the last repeater.

a. Circuit Terminated at Repeater Preceding Point of Failure. The procedure to be followed where the system is to be terminated at a repeater and connected by a two-wire circuit to a switchboard or a telephone set a short distance away is outlined below. The missing terminal is assumed to be terminal B.

(1) At terminal A, set the channel 1 GAIN potentiometer to step 17. Set the GAIN potentiometers of channels 2, 3, and 4 to step 12.

(2) At the repeater where the system is to be terminated set the dials of the equalizer panel as shown in table XXI.

Table XXI

Dial designation	AB equalizer panel	BA equalizer panel
Miles	Normal step	0
1	Normal step	10
4	0	0
2	4	4

(3) At the repeater connect the AB OUT binding post to the BA IN binding post.

(4) Transmit test power from terminal A on channel 1.

(5) At the repeater where the system is to be terminated, adjust dial 1 on the AB equalizer panel to obtain an output of −5 db.

(6) Adjust dial 1 on the BA equalizer panel to obtain and output of 0 dbm.

(7) At terminal A, adjust the GAIN potentiometer of channel 1 to obtain two-wire output of −10 dbm.

(8) At the repeater connect the two-wire extension to the AB OUT binding post. Talk between the end of the extension circuit and terminal A. In the talking condition, the over-all circuit net loss will be about 8 or 10 db in each direction plus the loss of the two-wire extension if the net losses cannot be reduced without dangerous singing difficulties or excessive echo and side tone conditions.

(9) To compensate for cable attenuation changes, periodically repeat steps (4), (5), (6), and (7) above. These adjustments should be made

with the two-wire extension circuit disconnected from the AB and OUT binding posts at the repeater where the system is terminated.

b. Circuit Terminated by Connecting to Cable Beyond Last Repeater. Where service is required at the end of the cable but a terminal is missing, or to a point along the cable beyond the last repeater, proceed as follows:

(1) At terminal A, set the GAIN potentiometer of channel 1 on step 17, and for channels 2, 3, and 4 on step 12.

(2) At the repeater preceding the point at which the cable is to be terminated, set the dials on the equalizer panel as shown in table XXII.

Table XXII

Dial designation	AB equalizer panel	BA equalizer panel
Miles	Normal step	Normal step.
1	Normal step	Normal step.
4	0	0.
2	4	4.

(3) At the end of the cable connect the two cable pairs together.

(4) At terminal A, transmit test power in channel 1.

(5) At the repeater, preceding the point at which the cable is terminated, adjust the output by means of dial 1 on the AB equalizer panel in accordance with table XXIII.

Table XXIII

Approximate distance to end of cable (miles)	AB output
5	+0
10	+5
15	+5
20	+10
25	+10

Where the repeater is equipped with an OUTPUT key the 5-dbm output is obtained by throwing the OUTPUT key lever to the +5DB position and adjust dial 1 of the AB equalizer panel until the meter reads 0 dbm. The +10-dbm output is obtained by throwing the OUTPUT key lever to the +10DB position and adjusting dial 1 until the meter reads 0 dbm. If the OUTPUT key is not provided, the +10-dbm output is obtained by adjusting dial 1 of the repeater preceding the point where the cable is terminated until the meter reads +5 dbm, and then increasing dial 1 five steps. Restore the MEAS key lever before making the five-step increase. If it is not possible to obtain an output of +5 dbm on step 25, the output at the preceding repeater should be increased until the limit is met. If the limit is not met, adjust for the maximum output.

(6) Adjust dial 1 of the BA equalizer panel at the repeater preceding the point where the cable is terminated until the output in the B to A direction of transmission is 0 dbm. If this limit is not met, adjust for maximum output.

(7) Adjust dial 1 of the BA equalizer panels of the succeeding repeaters between the point where the cable is terminated and terminal A for outputs of 0 dbm.

(8) At the receiving terminal, adjust dial 1 of the equalizer to obtain an output of the receiving amplifier of 0 dbm, and then adjust the GAIN potentiometer of channel 1 to obtain a two-wire output of −10 dbm.

(9) Connect the cable pairs which have been connected together to the switchboard of a field telephone set.

(10) To compensate for attenuation changes in the cable, periodically repeat steps (4) through (8) above. During these measurements the two-wire line should not be terminated at the distant end.

111. Operation With Dry Batteries

a. The normal power supply arrangements provide 6.3 volts and 60 volts alternating current and 150 volts direct current. If the 115- or 230-volt a-c supply has failed and the 12-volt storage batteries are not available, or if trouble should occur in the power supply equipment which cannot readily be repaired, carrier terminal and repeater equipment can be operated temporarily from dry-cell batteries. The equipment for a terminal includes two power supply circuits and in the emergency arrangements each supply circuit is treated separately. Both power supply circuits may be operated from one 12-volt storage battery if necessary.

b. Each power supply panel feeds two 6.3-volt circuits and one 150-volt circuit. In addition, one power panel supplies a 60-volt a-c circuit for operation of the signal bell. The drain of each 6.3-volt circuit varies between 1 and 1.5 amperes, depending upon the circuit, which is an appreciable drain for dry batteries. To prevent too frequent changing of the batteries, the use of two or more series-parallel strings of five 1.5-volt heavy duty A batteries in series to supply the circuits for each power supply panel is recommended. Table XXIV indicates the approximate

life which may be expected from one, two, or three parallel strings, assuming an allowable minimum voltage of 5.5 volts.

Table XXIV

Number of 7.5-volt battery strings per power supply circuit	Approximate life (hours)
1	4 to 5
2	15 to 20
3	40 to 60

The 150-volt drain is approximately 60 milliamperes per supply circuit. This may be supplied by three or four heavy duty 45-volt B batteries in series. Assuming a minimum allowable voltage of 120 volts, three batteries would last about 15 hours, and four batteries would last 40 to 50 hours. The initial use of four batteries is recommended. During the temporary period of operation on dry-cell batteries the signal bell will be inoperative and frequent monitoring of the system will be necessary until normal power is again available.

c. Dry batteries may be connected to the equipment at the OUTPUT terminal strip on the power supply panel. The regular power supply circuit is first disconnected by removing the lugs on terminals 1, 3, and 5 at the bottom of the terminal strip. The lugs on terminals 2, 4, and 6 are left in place to provide the equipment ground for each circuit. The batteries are then connected to the terminals as given in table XXV.

Table XXV

Terminals on QUTPUT strip	Battery terminals
1	Negative terminal of first 7.5-volt string.
2	Positive terminal of first 7.5-volt string.
3	Negative terminal of second 7.5-volt string.
4	Positive terminal of second 7.5-volt string.
5	Positive terminal of 180-volt string.
6	Negative terminal of 180-volt string.

The wiring between the dry batteries and the equipment should be as short as practicable, and care should be taken in connecting the batteries since no fusing is provided under this type of operation. To conserve the batteries, the 1,000-cycle oscillator at the terminals should be turned off when not in use. A frequent check of the repeater on terminal outputs should be made and the batteries replaced when the normal output cannot be obtained by adjusting the gain control dials.

PART THREE

PREVENTIVE MAINTENANCE

Section IX. PREVENTIVE MAINTENANCE TECHNIQUES

112. Meaning of Preventive Maintenance

Preventive maintenance may be defined as a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptious in service, and to eliminate major break-downs. To appreciate the meaning of the term *preventive* maintenance, it is necessary to distinguish between preventive maintenance and trouble shooting and repair. The primary function of preventive maintenance is to *prevent* breakdowns and the consequent necessity for repair. In sharp contrast, the primary function of trouble shooting and repair is to locate and correct existing defects. The importance of preventive maintenance cannot be overemphasized. The usefulness of the entire system of carrier communication depends upon the equipment being ready to operate at peak efficiency when needed.

Note.—The operations in section IX are first- and second-echelon (organization operators and repairmen) maintenance. Some operations in section XII are higher echelon maintenance.

113. Description of Preventive Maintenance Techniques

a. General. Most of the electrical parts used in Telephone Terminal Sets TC–21–A and TC–21–B and Repeater Set TC–23 require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because maintenance techniques cannot be applied indiscriminately, definite and specific instructions are needed. This section of the manual contains this type of specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations: namely, FEEL, INSPECT, TIGHTEN, CLEAN, ADJUST, and LUBRICATE. Throughout this manual the lettering system for the six operations will be as follows:

F—Feel
I—Inspect
T—Tighten
C—Clean
A—Adjust
L—Lubricate

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field requirements. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in climatic conditions (such as heavy rains followed by blistering heat), or excessive dampness, snow, and ice tend to cause deterioration of exposed surfaces and parts.

b. Feel (F). The feel operation is used most extensively to check rotating machinery (such as blower motors, drive motors, and generators) for overheated bearings. Feeling may indicate the need for lubrication or the existence of some other type of defect requiring correction. Normal operating temperature of a motor bearing is that temperature which permits holding the bare hand in contact with the motor-bearing cover for a period of 5 seconds without feeling any discomfort. The feel operation is also applied to a few items other than rotating machinery; the feel operation for these items is explained in the discussion of each item.

Note.—It is important that the feel operation be performed as soon as possible after the shut-down; and always before any other maintenance is done.

c. Inspect (I). (1) *General.* Inspection is probably the most important of all the preventive maintenance operations. If more than one man is available to do this work, choose the most observant, for careful observation is required to detect defects in the functioning of moving parts and any other abnormal conditions. To carry out the inspection operation most effectively, make every effort to become thoroughly familiar with normal operating conditions and to be able to recognize and identify abnormal conditions readily.

(2) *Inspection.* Inspection consists of carefully observing all parts in the equipment, noticing their color, placement, cleanliness, etc. Inspect for the following conditions:

(*a*) Overheating, as indicated by discoloration, blistering, or bulging of the part or surface of the container, leakage of insulating compounds, and oxidation of metal contact surfaces.

(*b*) Placement, by observing that all leads and cabling are in their original positions.

(*c*) Cleanliness, by carefully examining all recesses in the units for accumulated dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(*d*) Tightness, by testing any connection or mounting which appears to be loose, by slightly pulling on the wire, or by feeling the lug or terminal screw.

d. TIGHTEN (T). Any movement of the equipment caused by transportation, by concussion from falling shells, or by vibration from moving machinery, may result in loose connections which are likely to impair the operation of the set. The importance of firm mountings and connections cannot be overemphasized; however, never tighten screws, bolts, and nuts unless it is known definitely that they are loose. Fittings that are tightened beyond the pressure for which they are designed will be damaged or broken. When tightening, always be certain to use the correct tool of the proper size.

e. CLEAN (C). When the schedule calls for a cleaning operation, it does not mean that every item which bears that identifying letter must be cleaned each time it is inspected. Clean parts only when inspection shows that it is necessary. The cleaning operation to be performed on each part is described in paragraphs 114 to 126.

Note.—Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry Cleaning, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent (SD) is not on hand. Carbon tetrachloride will be used as a cleaning fluid only in the following cases: where inflammable solvents cannot be used because of the fire hazard, and for cleaning electrical contacts including relay and key contacts, plugs, commutators, etc.

f. ADJUST (A). Adjustments are made only when necessary to restore normal operating conditions. Specific types of adjustment are described in paragraphs 117, 119, 120, and 122.

g. LUBRICATE (L). Lubrication means the addition of oil or grease to form a film between two surfaces that slide against each other minimizing mechanical wear from friction. Generally, lubrication is performed only on motors, engines, and shafts.

114. Relays

a. GENERAL. Before applying preventive maintenance techniques to relays, determine whether a given relay is *normal* or *abnormal.*

(1) A relay is considered *normal* if:

(*a*) The exterior is free from dirt or dust.

(*b*) The contacts are not burned, pitted, or corroded.

(*c*) The contacts are lined up and correctly spaced.

(*d*) The contact springs are in good condition.

(*e*) The moving parts travel freely and function satisfactorily.

(*f*) The connections to the relay are tight.

(*g*) The wire insulation is not frayed or torn.

(*h*) The relay assembly is securely mounted.

(*i*) The coil shows no signs of overheating.

(2) A relay is considered *abnormal* if it fails to meet any of the nine requirements of a normal unit.

b. INSPECT (I). (1) Inspect the relay to detect abnormalities, using the check list given above. If the contacts are not readily accessible, they should be examined with the aid of a flashlight and mirror. Many of the relays can be inspected and cleaned and have their contacts cleaned without being removed from their mountings or taken apart.

(2) Check the mechanical action of the relays to make certain that when the moving and stationary contacts come together they make positive contact and are directly in line with each other. The armature or plunger mechanism should move freely without binding or dragging. Do not damage or misalign the relay mechanism.

c. TIGHTEN (T). Tighten all loose connections and mounting screws, but do not apply enough force to damage the screws or break the parts. If a screw does not turn easily, remove it and begin again.

d. CLEAN (C). (1) Wipe the exterior of the relay and the cover with a dry or damp cloth. If the relay cover is very dirty, clean it with a cloth or brush dipped in dry-cleaning solvent (SD). Wipe the surface with a dry cloth to remove the white deposit left by the solvent when it dries.

(2) Contacts ordinarily do not require cleaning. However, dust and dirt conditions may require that contacts be cleaned periodically as prescribed locally by one of the methods outlined below:

(*a*) Draw a burnishing blade between two contacts as they are held together gently with the fingers. If excessive dirt is present, flush the contacts by dipping a toothpick in carbon tetrachloride and applying, or by dipping the burnishing blade in carbon tetrachloride and then drawing it between the contacts. Clean the burnishing blade with a dry, lint-free cloth and burnish the contacts again.

(*b*) Draw a strip of clean, lint-free cloth between the contacts while holding them gently together with the fingers. In some cases it may be necessary to moisten the cloth with carbon tetrachloride. Use a dry, lint-free cloth for polishing. Draw the blade of a burnishing tool between the contacts to remove any dirt or lint which may have adhered to the contacts.

(3) Recheck the operation of the relay, noting in particular the making and breaking of contacts.

115. Cords and Cables

The cables can be regarded as the life lines of the equipment. The condition of the cabling must be closely observed. Mobile equipment, operated in all kinds of weather and moved on all kinds of roads, subjects cabling to a great deal of punishment.

a. INSPECT (I). (1) Inspect the cables for cracked or deteriorated insulation, frayed or cut insulation at the connecting and supporting points, and improper placement which places the cables or connections under strain. Watch for kinks and improper supports.

(2) Several ground connections are used in the cabling system. These should be kept clean and tight. If any one of the grounded points is open, it may interfere with the operation of the equipment.

(3) If the frame of the equipment is grounded at a loose point, the loose connection nullifies protection for the operating personnel.

b. TIGHTEN (T). Tighten loose cable clamps, coupling rings, and cable connections.

c. CLEAN (C). Clean connections on cables when they are dirty or corroded. The easiest way to clean a dirty connector is to remove it, scrub it with a brush dipped in dry-cleaning solvent, and dry it thoroughly with a cloth. Clean corroded connectors with #0000 sandpaper. It is important that the entire surface of the connector be clean. No attempt should be made to remove individual prongs from cable plugs.

116. Protectors

a. INSPECT (I). Inspect the protectors to make sure that the carbon blocks are clean.

b. CLEAN (C). Clean the carbon blocks by rubbing the flat surfaces together or by rubbing the surfaces with a very fine abrasive cloth. Reinsert the blocks.

117. Batteries

a. INSPECT (I). Inspect the battery receptacle and replace the battery if it is cracked or broken. Check the battery cables for deterioration of rubber, excess wear, cuts, and kinks. Replace if necessary. Inspect the exterior metal parts of the battery, such as connectors and terminals, for corrosion. Check the specific gravity of the electrolyte. (See par. 77.)

b. TIGHTEN (T). When necessary, tighten the wingnuts which hold the battery connectors in place.

c. CLEAN (C). (1) Clean connectors with a cloth or, if necessary, with metal polish or crocus cloth. If metal polish is used, remove all residue of the polish after the cleaning operation to maintain good contact.

(2) Brush corroded parts with a wire brush. Apply a mixture of bicarbonate of soda and water of the consistency of thin cream to the metal parts, making fresh applications until the acid has been neutralized by the solution. Complete neutralization is indicated when the bubbing action stops.

Caution: Do not allow the bicarbonate of soda solution to enter the interior of the battery through the vent operations.

(3) Remove grease and oil from the cable and associated parts with a soft cloth dampened with dry-cleaning solvent.

d. ADJUST (A). If the specific gravity of the battery is low, recharge the battery. (See pars. 177 and 178.)

118. Cases

a. INSPECT (I). Inspect the cases both inside and outside for dirt, chipped paint, and deep scratches. The edges of the case and the covers should be smooth, not chipped or splintered. Repair and repaint if necessary. (See par. 181.) Check the condition of the trunk drawbolts. They should be fastened securely to the case and lock easily. Inspect the drawbolts, bolts, carrying handles, and skids for rust.

b. TIGHTEN (T). Tighten the bolts that fasten the U-channels to the sides of the case. Tighten the screws that fasten the drawbolts, skids, and carrying handles to the case.

c. CLEAN (C). Clean the inside and outside of the case to prevent dirt and dust from getting into the equipment.

119. Meters

Meters are extremely delicate instruments and must be handled very carefully. They require little maintenance. They are precision instruments and cannot be repaired in the field. A damaged meter should be replaced with a spare and returned to the depot for repair.

a. INSPECT (I). Inspect the leads and connections to the meter. Look for loose, dirty, and corroded connections. Look for cracked or broken cover glasses. Since the movement of a meter is extremely delicate, its accuracy will be seriously affected if the glass is broken and dirt and water filter through.

b. TIGHTEN (T). Tighten all loose connections and screws. Inspect all loose meter wires for dirt or corrosion before they are tightened. The tightening of meter connections requires a special technique because careless handling can easily crack the meter case. To prevent breakage, hold the retaining nut which makes contact with the meter case firmly while the outside nut is being tightened. This permits tightening of the connections without increasing the pressure of the head of the stud against the inside of the meter case.

c. CLEAN (C). (1) Meter cases are made of hard, highly polished bakelite and can usually be cleaned with a dry cloth. If cleaning is difficult, the cloth should be dampened with dry-cleaning solvent. Clean dirty connections with a small stiff brush dipped in dry-cleaning solvent or with a small piece of cloth dipped in the solvent. Solvents do not entirely remove dirt from hard surfaces. Some of the dirt will be left in a softened state and must be removed with a clean cloth.

(2) Clean corroded connections by sanding them lightly with a very fine grade of sandpaper, such as #0000. After they are cleaned, wipe the connections carefully with a clean cloth.

d. ADJUST (A). Normally, meters should indicate 0 when the equipment is turned off. The procedure for setting the meter to 0 is not difficult. The tool required is a very thin-tipped screw driver. Before adjusting a meter, tap the meter case lightly with the tip of one finger. This will help the meter to overcome the slight friction which sometimes exists at the bearings and prevents an otherwise normal unit from coming to rest at 0. If adjustment is needed, insert the tip of the screw driver in the slotted screw head located below the meter glass and slowly turn the adjusting screw until the pointer is at 0. View the meter face and pointer full on and not from either side. Avoid turning the screw too far because the needle may be bent or the hairspring damaged. After adjusting the meter, tap the meter case to assure that the meter needle will remain on the adjusted position.

120. Vacuum Tubes

This section of the manual does not deal with each tube, each resistor, and each capacitor of the equipment. Rather, it combines all the instructional material on the major classes of parts and devices.

a. GENERAL. Preventive maintenance for vacuum tubes includes inspection, cleaning and testing. Preventive maintenance for tube sockets and mountings involves inspection, tightening, adjusting, and cleaning. Each of these operations will be discussed in detail below.

Note.—Avoid working on the tubes immediately after shut-down. Severe burns may result from contact with the envelopes of hot tubes.

b. INSPECT (I). (1) Examine glass and metal tube envelopes, tube caps, and tube connector clips for accumulation of dirt and for corrosion. Watch for tube caps which have been broken away from the cement that attaches them to the glass envelopes, and for tube envelopes that have broken away from the tube base. If suitable replacements are not available, repair should not be attempted, but a record should be kept so that replacement will be made at the earliest opportunity.

(2) The firmness of tubes in their sockets must be determined by inspection. Make the inspection by pressing the tubes down in the sockets and testing them in that position, and *not* by partly withdrawing the tubes and jiggling them from side to side. Movement of a tube tends to weaken the pins in the base and unnecessarily spreads the contacts in the socket. Trouble will occur where it did not exist before. It is desirable to inspect the sockets of the tubes at the time the tubes are removed. If there is a reason to believe that a socket is faulty and responsible for improper operation, it should be checked.

(3) Be careful when removing a tube from its socket, especially if it is a high-power tube. A

warm tube must never be jarred. It is important to store tubes carefully after they have been removed from the sockets. They should not be placed on elevated flat surfaces without proper precautions to prevent their rolling to the ground or floor. They are not to be placed on the floor of the trailer where they might be kicked or stepped upon.

c. TIGHTEN (T). Tighten all loose connections in the tube sockets or on the tubes. If the connections are dirty or corroded, clean before tightening. When tightening locknuts that hold the sockets to the insulated bushing, do not apply excessive pressure. Too much pressure will crack the bushing. Socket mountings must be tight at all times. Otherwise, during transit they will be loosened, and the tubes in them may become irreparably damaged.

d. CLEAN (C). (1) Clean the tubes, but only if inspection shows cleaning to be necessary. Tubes operating at low voltages and not having exposed grid and plate caps do not require detailed cleaning. Dirt should not be permitted to accumulate on low-voltage tubes.

(2) Do not remove tubes from their sockets for cleaning. Instead they should remain in place. The danger of breakage is great. The scarcity of replacement parts justifies every precaution.

(3) The cleaning of tubes calls for removing dust and dirt from the glass or metal envelopes. Use a clean, lint-free, dry cloth.

(4) When tube sockets are cleaned and the contacts are accessible, fine sandpaper may be used to remove corrosion, oxidation, and dirt.

Caution: Before maintenance work is begun, it is absolutely necessary for the safety of personnel to *short-circuit all high-voltage capacitors* with a well-insulated screw driver or with a capacitor-shorting tool.

e. ADJUST (A). (1) Adjust loose tube connections. Do not adjust the socket contact springs unless inspection indicates clearly that this is necessary.

(2) Adjust the tension of socket contact springs. Do not bend the spring. Instead, place the tips of the long-nose pliers on the spring near its point of attachment to the socket base; then gently apply pressure in the direction in which increased tension is required. Repeat this action as the pliers are moved toward the contact end of the spring. The result will be a slight bow in the spring, but the desired effect will be produced.

121. Keys and Switches

a. INSPECT (I). (1) Inspect the mechanical action of each key or switch and look for signs of dirt or corrosion on all exposed elements. In some cases, examine the elements of the key or switch visually. Where possible, examine the action of the key or switch by flipping the control knob or toggle or by pressing the switch button and noting the freedom of movement and the amount of spring tension. Inspect the gang switches visually to see if the contacts are clean. Do not pry the leaves of the switch apart. Some contacts are silver-plated and do not corrode easily. The rotary member should make good contact with the stationary member, and as the former slides into the latter a spreading of the contact leaves should be noticeable.

(2) For inspection, remove the covers of switches where necessary. Throw each switch and observe the action of the switch elements. The springs should have ample tension. The switch action should be free. The contacts should be clean. Brown or black stain on a silver-plated contact should not be confused with dirt or corrosion. It is silver oxide and is a satisfactory conductor. The wiping action of the contacts usually removes the silver oxide at the point of contact.

b. CLEAN (C). Clean the exterior surfaces of keys and switches with a stiff brush moistened with dry-cleaning solvent, and polish with a piece of cloth. Clean all key and switch contacts in the same way as relay contacts. When the contacts have deep pits caused by burning or arcing, use the burnishing tool to resurface them.

122. Rheostats

a. INSPECT (I). (1) Inspect the mechanical condition of the rheostats. The arm should be keyed tightly to the shaft, and the shaft should turn easily in the bushing which supports it. If the arm is loose, inspect the bushing that holds it to the shaft to see whether the bushing is worn or broken. Poor contact between the arm and the resistor winding is caused by insufficient tension in the arm. If the shaft is positioned by a compression spring, the spring should be inspected for breakage.

(2) Inspect the assembly and mounting screws, setscrews, and nuts.

(3) Inspect the insulating body of the rheostat for dust, cracks, or chipped places.

(4) Inspect all metallic parts for dust, dirt, and corrosion.

b. TIGHTEN (T). Tighten loose assembly or mounting screws. Usually the heads of the mounting screws are easily accessible since they are located one on each side of the control knob on the front panel. In a few cases the screwheads are covered by the knob and it is necessary to remove the knob to tighten them. To remove the knob, rotate the knob counterclockwise as far as it will go and mark the position of the pointer on the panel. Loosen the setscrew and remove the knob. Tighten the mounting screws and replace the knob, using the mark on the panel to position it correctly.

c. CLEAN (C). (1) Clean the contact surface of the resistance winding, the sliding contact, the body of the rheostat, and the connections whenever they are dirty or corroded.

(2) Remove grease and dirt from the rheostat parts with dry-cleaning solvent.

(3) If the contact surfaces are corroded, clean them with the crocus cloth.

(4) To clean the contact surface of the arm, insert a crocus cloth stick between the arm and the rheostat winding and draw the stick back and forth. A strip of crocus cloth can be used for this purpose.

(5) Clean the body of the rheostat with a brush or cloth.

d. ADJUST (A). Adjust the tension in the contact arm to insure positive contact. Use a pair of long-nose pliers to spring the arm slightly in the direction in which the tension is desired. Do not make a sharp bend at any one place. Work the pliers along the length of the contact arm and put a slight bow in it. Do not damage the winding.

e. LUBRICATE (L). If the shaft turns hard in its bushing, a drop or two of special preservative lubricating oil (PS) may be placed on the shaft at each end of the bushing. After lubrication, the surrounding surfaces must be wiped with a dry cloth.

123. Terminal Blocks

Terminal blocks are used as receiving, connecting, and distributing points for electrical circuits. Their construction is simple. They consist of a strip of insulation with connections mounted on it. Little preventive maintenance is needed on the terminal blocks especially if the equipment has not been moved. The following paragraphs describe their care:

a. INSPECT (I). (1) Inspect the terminal blocks for cracks, breakage, dirt, and loose connections or mounting screws.

(2) Carefully examine the connections for mechanical defects, dirt, and corrosion.

b. TIGHTEN (T). Tighten loose screws, lugs, and mounting bolts. When tightening screws, be sure to select a screw driver of the correct size. Do not exert too much pressure. Remove loose connections and clean them when they are dirty or corroded.

c. CLEAN (C). Clean the terminal blocks when they require it with a dry brush. When necessary, use a cloth moistened with dry-cleaning solvent. If a solvent is used, the block must be thoroughly wiped with a brush to remove the lint.

124. Capacitors

a. INSPECT (I). (1) Inspect the terminals of the capacitors for corrosion and loose connections. The mountings should be carefully inspected for any loose mounting screws, studs, or brackets. Examine the leads for poor insulation, for cracks, and for evidence of dry rot. Cut away frayed strands on the insulation. If the wire is exposed, wrap it with friction tape. The terminals of the capacitors should not be cracked or broken.

(2) The case of each capacitor must be thoroughly inspected for leaks, bulges, and discoloration.

b. TIGHTEN (T). (1) Tighten loose terminals, mountings, and connections on the capacitors.

(2) Carefully tighten the retaining nuts of the capacitors. When tightening a nut, be careful not to break the bushing or damage the gasket.

c. CLEAN (C). (1) Clean the case of the capacitor, the insulating bushings, and any connections that are dirty or corroded. The capacitor cases and bushings can usually be cleaned with a dry cloth, but if the deposit of dirt is difficult to remove, moisten the cloth in dry-cleaning solvent.

(2) Carefully dry the bushings with a dry cloth after they are cleaned. Corroded connections should be sanded with fine sandpaper and then tightened.

125. Resistors

a. INSPECT (I). Inspect the coating of vitreous resistors for signs of cracks and chipping, especially at the ends. Examine the bodies of all types of resistors for blistering, discoloration, and other indications of overheating. Inspect leads, clips, the metallic ends of ferrule type resistors, and all other connections for corrosion, dirt, dust, looseness, and broken strands in the connecting wires. Check the security of all mountings. Do not attempt to move resistors with pigtail connections because there is danger of breaking the connec-

tions at the point where they enter the body of the resistor. Such defects cannot be repaired.

b. TIGHTEN (T). Tighten resistor connections and mountings whenever they are loose. If a resistor is allowed to remain loose, vibration may break the connection or damage the body. The tension of the clips may be increased by compressing them with the fingers or with a pair of pliers. Using the fingers is preferred.

c. CLEAN (C). (1) Clean all dirty or corroded connections on the resistors, using a cloth or a brush dipped in dry-cleaning fluid. If the resistors are corroded, it will be necessary to sand them lightly with a fine grade of sandpaper and then wipe them clean with a dry cloth.

(2) The large vitreous enameled resistors must be kept clean to avoid flash-overs or leakage between terminals. They will ordinarily be wiped with a dry cloth. However, if the dirt deposit is unusually difficult to remove, use dry-cleaning solvent.

(3) Resistors with discolored bodies cannot be cleaned. Discoloration is indicative of overloading at some time prior to the inspection and is probably due to circuit trouble which requires analysis.

126. Transformers and Filter Chokes

Almost without exception, transformers and chokes must be replaced if defective, but preventive maintenance techniques give some amount of protection against failure at inopportune times.

a. FEEL (F). Feel wax-impregnated transformers for signs of overheating. The surest sign of overheating is the presence of insulating compound on the outside of the seams of the case. Overheating is an indication of circuit trouble and requires a system analysis.

b. INSPECT (I). Inspect transformers and chokes for general cleanliness and for tightness of connections, connecting lugs or terminals, mounting brackets, and rivets. Dust, dirt, or moisture between terminals of high-voltage transformers or on chokes located at high-potential points in the circuit may cause flash-overs.

c. TIGHTEN (T). (1) Tighten loose mounting screws or connections *immediately*.

(2) If it is necessary to remove wires to tighten loose parts, note the position of the wires before they are unsoldered and restore them to their original places.

d. CLEAN (C). (1) Clean the cases of the transformers and chokes with a dry cloth. In a few instances it may be desirable to use dry-cleaning solvent to remove foreign matter.

(2) Corroded connections can be sandpapered and wiped clean.

(3) Clean corrosion from ground connections and from resoldered connections.

Section X. PREVENTIVE MAINTENANCE CHECK LIST

127. Preventive Maintenance Check List

The following check list is a summary of the preventive maintenance to be performed on Telephone Terminal CF–1–(*) and Repeater CF–3–A. The echelon column indicates which operations are first echelon maintenance and which operations are second-echelon maintenance. Operations are indicated by the letters of the word FITCAL. For example, if the letters ITCA appear in the "Operations" column, the item to be treated must be inspected (I), tightened (T), cleaned (C), and adjusted (A).

128. Preventive Maintenance Check List for Telephone Terminal CF–1–(*) and Repeater CF–3–A

Item No.	Operations	Item	When performed			Echelon
			Weekly	Monthly	Semi-annually	
1	ITC	Relays (par. 114)	x			2d
2	ITC	Cords and cables (par. 115)	x			2d
3	IC	Protectors (par. 116)	x			2d
4	ITCA	Batteries (par. 117)	x			2d
5	ITC	Cases (par. 118)	x			2d
6	ITCA	Meters (par. 119)	x			2d
7	ITCA	Vacuum tubes (par. 120)		x		2d
8	IC	Keys and switches (par. 121)		x		2d
9	ITCAL	Rheostats (par. 122)		x		2d
10	ITC	Terminal blocks (par. 123)		x		2d
11	ITC	Capacitors (par. 124)			x	2d
12	ITC	Resistors (par. 125)			x	2d
13	FITC	Transformers and chokes (par. 126)			x	2d

F	I	T	C	A	L
Feel	Inspect	Tighten	Clean	Adjust	Lubricate

Section XI. LUBRICATION

Note.—A War Department Lubrication Order is not issued on Telephone Terminal CF–1–(*) or Repeater CF–3–A. See section IX for the lubrication instructions for these equipments.

Section XII. MOISTUREPROOFING AND FUNGIPROOFING

129. General

When operated in tropical areas, where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are some of the problems met:

a. Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

b. Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual breakdown.

c. Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

d. Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs and crosstalk.

e. Moisture provides leakage paths between battery terminals.

130. Treatment

A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment consists of the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. See TB SIG 13, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required.

Caution: Varnish spray may have poisonous effects if inhaled. To avoid inhaling the spray, use a respirator if available; otherwise, fasten cheesecloth or other cloth material over the nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

131. Telephone Terminal CF–1–(*)

a. PREPARATION. Make all repairs and adjustments necessary for proper operation of the equipment.

b. DISASSEMBLY. (1) *Carrying case.* Remove the front and rear covers of the carrying case (not to be treated).

(2) *Line coil and binding post panel.* Remove the binding post panel from its mountings. Do not disconnect.

(3) *Measuring panel.* (*a*) Remove the knob and the shaft pin of the circuit selector switch on the meter panel.

(*b*) Remove the meter panel from its mounting. Do not disconnect.

(4) *Equalizer panel.* Remove the front panel from its mounting. Do not disconnect.

(5) *Channels 1, 2, 3, and 4 panels (as a single unit).* (*a*) Remove the LEVEL control panel from its mountings on the channel 1 panel. Do not disconnect.

(*b*) Remove the four GAIN control knobs and their shaft pins (not to be treated).

(*c*) Remove the four control panels from their mountings. Do not disconnect.

(6) *Signal panel (Telephone Terminal CF–1–A).* (*a*) Remove the CALLING SIGNAL & LINE ALARM panel from its mounting. Do not disconnect.

(*b*) Remove the two signal lamps (not to be treated).

(7) *Talk and signal panel (Telephone Terminal CF–1–B).* (*a*) Remove the CALLING SIGNAL & LINE ALARM panel from its mounting. Do not disconnect.

(*b*) Remove the CHANNEL TERMINATION key panel from its mounting. Do not disconnect.

(*c*) Remove the two signal lamps (not to be treated).

(8) *Power supply panels A and B (as a single unit).* (*a*) Remove the front covers (not to be treated).

(*b*) Remove the four frequency generators (to be treated).

c. CLEANING. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

d. MASKING. (1) *Front of terminal.* (*a*) *Lien coil and binding post panel.*

1. Cover the protectors on the left and the spare protectors immediately above the panel.
2. Cover the front of the binding post panel

(*b*) *Measuring panel.*

1. Cover the front of the meter panel.
2. Cover the shaft and bushing of the selector switch.

3. Cover the transfer key on the meter panel so that the operating mechanism and spring contacts are protected and soldering lugs and insulating spares are exposed.

(*c*) *Equalizer panel.*

1. Cover the face of the front panel.
2. Cover the rear of each attenuator to prevent the varnish from sealing the dust covers.

(*d*) *Channels 1, 2, 3, and 4 panels (as a single unit).*

1. Cover the front of the LEVEL control key (or keys) on the channel 1 panel.
2. Cover the fronts of the four control panels.
3. Cover the shafts and bushings of the four GAIN controls.
4. Cover all transfer keys so that the operating mechanisms and the spring contacts are protected and soldering lugs and insulating spacers are exposed.

(*e*) *Signal panel (Telephone Terminal CF–1–A).*

1. Cover the front of the CALLING SIGNAL & LINE ALARM panel.
2. Cover the transfer keys so that the operating mechanisms and the spring contacts are protected and the soldering lugs and insulating spacers are exposed.
3. Mask the tops of the signal lamp sockets.
4. Cover the S relay cover and its cover clamp.
5. Mask the TEL binding posts.

(*f*) *Talk and signal panel (Telephone Terminal CF–1–B).*

1. Cover the front of the CALLING SIGNAL & LINE ALARM panel.
2. Cover the front of the CHANNEL TERMINATION panel.
3. Cover the transfer keys on both panels so that the operating mechanisms and the spring contacts are protected and the soldering lugs and insulating spacers are exposed.
4. Mask the tops of the signal lamp sockets.
5. Cover the S relay cover and its cover clamp.
6. Coil up the handset cord and include both cord and handset in a common cover.

(*g*) *Power supply panels A and B (as a single unit).*

1. Mask the tops of the four frequency generator sockets.
2. Cover the two R relays.
3. Mask the AC and AC1 caps of the extractor type fuse holders.
4. Mask the double fuse holders near the R relays.
5. Mask the ground binding post on the right-hand side of each power supply panel.
6. Mask the varistor rectifiers.

(2) *Rear of terminal.* (*a*) *Measuring panel.*

1. Cover the selector switch.
2. Mask the bottom of the vacuum-tube socket.

(*b*) *Line amplifier panel.* Mask the bottom of each vacuum-tube socket (eight in all).

(*c*) *Channels 1, 2, 3, and 4 panels (as a single unit).*

1. Cover the rear of each GAIN control to prevent the varnish from sealing the dust cover.
2. Mask the bottom of each vacuum-tube socket (seven in all).
3. Mask the screw driver adjustment of the C oscillator coils located at the lower middle of the channels 2, 3, and 4 panels (*not* in channel 1 panel).

(*d*) *Signal panel.*

1. Cover the bottoms of the signal lamp sockets.
2. Cover the S relay and panel cut-out.

(*e*) *Spare-tube panel.* Mask the bottoms of the spare-tube sockets.

(*f*) *Power cords and mountings.* Cover the a-c and battery power cords and the rubber shock mountings.

e. Drying. Place the equipment in oven or under heat lamps and dry for 4½ to 5 hours at 135° F. Do not exceed 135° F.

f. Varnishing. (1) Apply three coats of moistureproofing and fungiproofing varnish Lacquer, Fungus-resistant, spec. No. 71–2202 (stock No. 6G1005.3 or equal). Allow each coat to air-dry for 15 or 20 minutes before applying the next coat.

Caution: Do not use varnish which contains mercury on this equipment.

(2) Apply varnish immediately after the equipment is dried. If varnish is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

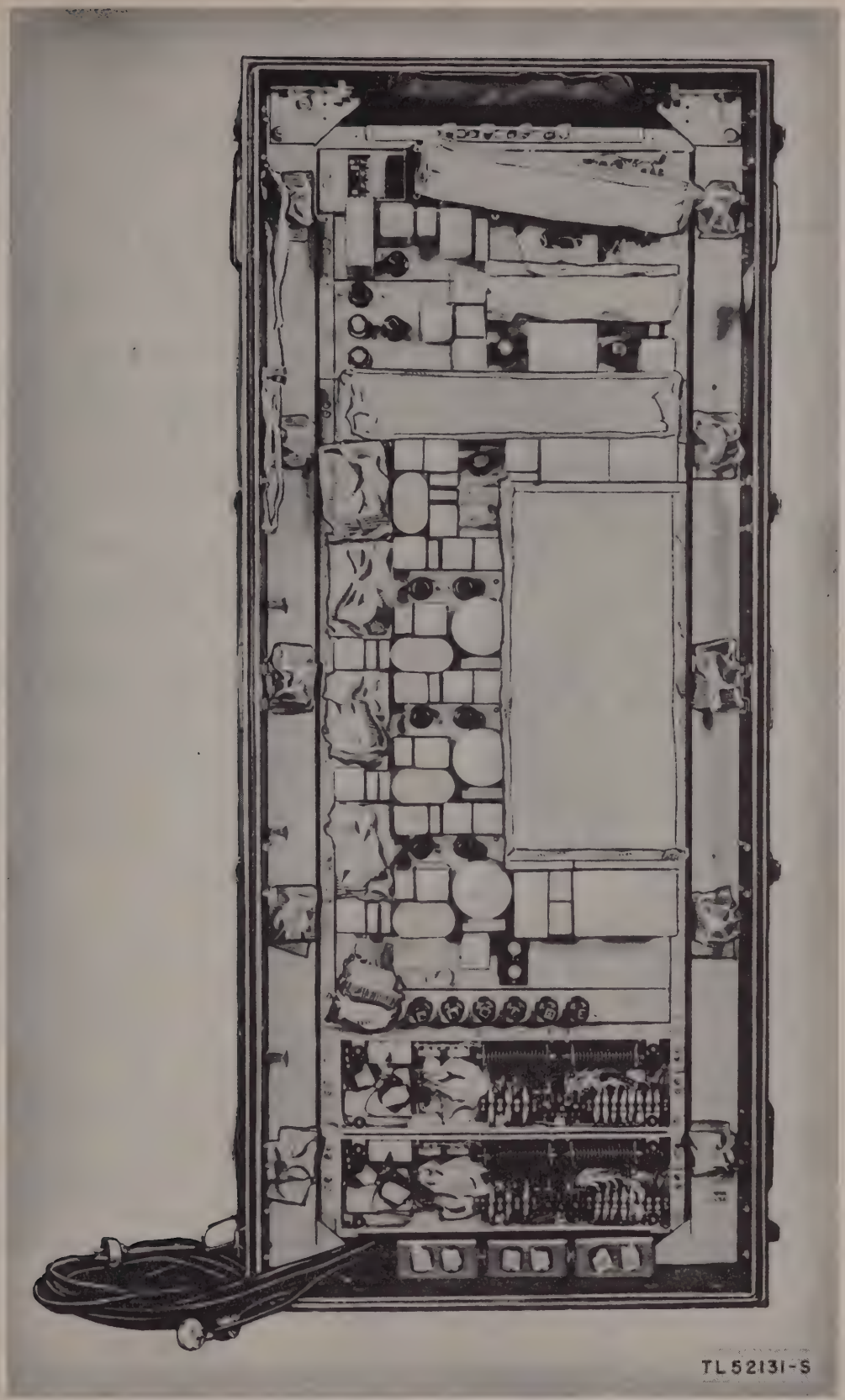

Figure 55. Telephone Terminal CF–1–A, front panel, masked for moistureproofing and fungiproofing treatment.

(3) Spray all exposed parts and wiring on the front and rear of the terminal.

(4) After three spray coats have been applied, remove all masking.

(5) Using a full brush, seal the following portions of the meter on the measuring panel:

(*a*) The joint between the back plate and the meter shell.

(*b*) The heads of the back plate retaining screws.

(*c*) The edge of the meter glass and zero-set adjustment.

(6) Remove the dust covers from the equalizer and GAIN controls (eight in all), and coat the inner surface of the bottom of each dust cover. Do not replace these covers until the varnish is dry.

(7) Brush the front of the binding post panel and the protector panel, being careful not to allow the varnish to run onto the binding posts and/or the protectors.

(8) Remove the S relay cover on the signal panel, and coat as much of the surface of the relay mechanism as possible without impairing its operation.

(9) Remove the cover of the signal bell (or buzzer), and brush the mechanism carefully.

(10) Brush the surfaces of the R relay (in the power supply) as completely as possible without impairing its operation.

(11) Brush the base of each frequency generator. Do not brush the base pins.

(12) Brush all wires and connections which were covered by the masking.

g. Reassembly. Reassemble the equipment and test its operation.

h. Marking. Mark the letters MFP and the date of treatment on the right-hand side of the carrying case where the name of the equipment has been stenciled.

Example: MFP—6 Apr 45.

132. Repeater CF–3–A

a. Preparation. Make all repairs and adjustments necessary for proper operation of the equipment.

b. Disassembly. (1) *Carrying case.* Remove the front and rear covers of the carrying case (not to be treated).

(2) *Power cords.* Lay the a-c and battery power cords out to one side and place a telephone cord in next to the hand set.

(3) *Line coil and measuring panel.* (*a*) Remove the binding post panel from its mounting. Do not disconnect.

(*b*) Remove the MEAS switch knob and its shaft pin (not to be treated).

(*c*) Remove the meter panel from its mounting. Do not disconnect.

(4) *Equalizer panels AB and BA.* Remove the front panels from their mountings. Do not disconnect.

(5) *Talk and signal panel.* Remove the control panel from its mounting. Do not disconnect.

(6) *Power supply.* (*a*) Remove the front cover (not to be treated).

(*b*) Remove the two frequency generators (to be treated).

c. Cleaning. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

d. Masking. (1) *Front of repeater.* (*a*) *Line coil and measuring panel.*

1. Cover the fronts of the binding post and meter panels.

2. Cover the shaft and bushing of the MEAS switch.

3. Cover the transfer keys on the meter panel so that the operating mechanisms and spring contacts are protected and soldering lugs and insulating spacers are exposed.

4. Cover the protectors.

(*b*) *Equalizer panels AB and BA.*

1. Cover the fronts of the equalizer panels.

2. Cover the rear of each attenuator to prevent the varnish from sealing the dust covers.

(*c*) *Talk and signal panel.*

1. Cover the transfer keys on the control panel so that the operating mechanisms are protected and the soldering lugs and insulating spacers are exposed.

2. Cover the S relay cover and cover clamp.

(*d*) *Power supply panel.*

1. Cover the R relay.

2. Mask the fronts of the frequency generator sockets.

3. Mask the AC and AC1 caps of the extractor type fuse holders.

4. Cover the double fuse holder.

(*e*) *Handset.* Cover the telephone handset and its cord.

(*f*) *Mountings.* Cover the rubber shock mountings.

(2) *Rear of repeater.* (*a*) Cover the selector switch on the line coil and measuring panel.

(*b*) Mask the bottoms of all vacuum-tube sockets on the line amplifier panel.

(*c*) Cover the S relay cut-out in the talk and signal panel.

(*d*) Cover the rubber shaft mounting.

e. DRYING. Place the repeater in oven or under heat lamps and dry for 4½ to 5 hours at 135° F. Do not exceed 135° F.

f. VARNISHING. (1) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71–2202 (stock No. 6G1005.3), or equal). Allow each coat to air-dry from 15 to 20 minutes before applying the next coat.

Caution: On this equipment do not use varnish which contains mercury.

(2) Apply varnish immediately after equipment is dried. If varnish is not applied immediately, moisture condenses on equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(3) Spray all exposed parts and wiring on the front and rear of the equipment.

(4) After three spray coats have been applied, remove all masking.

(5) Using a full brush, seal the following portions of the meter on the measuring panel:

(*a*) The point between the back plate and the meter shell.

(*b*) The heads of the back plate retaining screws.

(*c*) The edge of the meter glass and the zero-set adjustment.

(6) Remove the dust covers from the equalizer controls (eight in all), and coat the inner surface of the bottom of each cover. Do not replace these covers until the varnish is dry.

(7) Brush the front of the binding post and protector panels, being careful not to allow the varnish to run onto the binding posts and/or the protectors.

(8) Remove the S relay cover on the talk and signal panel, and coat as much of the surface of the relay mechanism as possible without impairing its operation.

(9) Remove the cover of the signal bell (or buzzer), and coat the mechanism carefully.

(10) Brush the surfaces of the R relay (in the power supply) as completely as possible without impairing its operation.

(11) Brush the base of each frequency generator. Do not brush the base pins.

(12) Brush all wires and connections which were covered by the masking.

g. REASSEMBLY. Reassemble the set and test its operation.

h. MARKING. Mark the letters MFP and the date of treatment on the right-hand side of the case where the name of the equipment is stenciled.

Example: MFP—6 Apr 45.

133. Moistureproofing and Fungiproofing After Repairs

If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

PART FOUR
AUXILIARY EQUIPMENT

(Not used)

PART FIVE

REPAIR INSTRUCTIONS

Note.—Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form 54 (Unsatisfactory Report). If either form is not available, prepare letter containing the data elicited by the sample form shown in figure 56 without reproducing copies of the form.

Section XIII. GENERAL REPAIR PROCEDURE

134. Trouble Location

a. When trouble is detected by routine testing, or trouble reports are submitted by using or operating personnel noting faulty operation or complete failure of the equipment, speedy repairs are more easily accomplished. The trouble should be isolated to the terminal, repeater, or line section, or some external portion of the equipment. Regular operational and line-up tests will aid in locating and isolating the source of trouble. Parts such as filters, resistors, capacitors, etc., may have to be replaced and the trouble located by a process of elimination when it is impossible to test all of the circuits of the equipment.

b. When a trouble is located, it may be corrected by replacement of a defective part or by adjustment of a circuit or component. The equipment then should be given a new over-all line-up, its operation tested from end to end, and restored to service.

135. Repair Techniques

a. The main objectives in repairing equipment are accuracy in location of trouble, skill and efficiency in repair, and speed in returning the system to normal and satisfactory service. To perform trouble location procedures and repairs, maintenance men must have a certain amount of knowledge and skill. A complete knowledge of the detailed functioning of the various parts and circuits in the equipment, skill in reading wiring and schematic diagrams, and a thorough knowledge of testing apparatus and its application are necessary to perform satisfactory repairs and prevent the recurrence of trouble.

b. Service failures can be kept to a minimum by careful handling of the equipment during installation and operation, and by being careful when making field repairs and adjustments. The wiring should not be disturbed any more than is necessary in testing and inspecting. If a soldering iron is used, do not drop splashes of solder on apparatus parts or wiring terminals.

136. Wiring Diagrams

Wiring diagrams of the channel and oscillator circuits are placed inside the rear covers of the terminal and repeater equipments. In these diagrams each piece of apparatus has the same marking as that stamped on the equipment, and the wiring terminals on each piece of apparatus are shown in their proper relative location as viewed from the wiring side. The diagrams are marked with the color and identification number of each wire so that trouble caused by faulty or broken equipment wiring may be more easily traced. Filters, equalizers, and gain control units are shown in block schematic form on these circuit labels. In case of trouble the entire unit must be replaced.

137. Unsatisfactory Equipment Report

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report, WD, AGO Form 468, should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form 54 should be filled out and forwarded through channels.

c. If either form is not available, prepare letter containing the data elicited by the sample form shown in figure 56 without reproducing copies of the form.

855662 O—49——7

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps — MATERIEL		DATE: 15 Apr 1945
FROM	ORGANIZATION: 249 Sig Repair Co.		STATION: APO 510, New York City
TO	NEXT SUPERIOR HEADQUARTERS: Signal Officer, Ninth Army	STATION: APO 510, New York City	TECHNICAL SERVICE: Signal Corps

COMPLETE MAJOR ITEM

NOMENCLATURE	TYPE	MODEL
Telephone Terminal (Carrier)	CF-1	A

MANUFACTURER	U. S. A. REG. No.	SERIAL No.	DATE RECEIVED
Eastern Electric Co.		528	3 Apr 1945

EQUIPMENT WITH WHICH USED (*if applicable*): Telegraph Terminal Set TC-22, Repeater Set TC-23, Ringer Set TC-24

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART No.	TYPE	MANUFACTURER	DATE INSTALLED
4Z9705	Rectifier, varistor	Eastern Electric Co.	6 Apr 1945

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (*If additional space is required, use back of form*): Varistor bridge TR unbalanced due to moisture.

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
9 Apr 1945			3				54		

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN: Poor transmission, poor quality. Repair attempted but unsuccessful. Varistor replaced.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (*If additional space is required, use back of form*)
POOR	FAIR	GOOD	
		✓	More positive type of moistureproofing.

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION	SIGNATURE
WILLIAM W. WILSON, Capt., Sig. C. 249 Sig. Repair Co.	William W. Wilson

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL53572-S

Figure 56. Form 468, War Department Unsatisfactory Equipment Report, sample form.

Section XIV. DETAILED FUNCTIONING OF EQUIPMENT

138. Functioning of Telephone Terminal CF–1–(*)

The general arrangement of the four telephone channels provided by two Telephone Terminals CF–1–(*) with Repeaters CF–3–A is outlined in paragraphs 64 to 67. Where there are differences in functioning of Telephone Terminals CF–1–A and CF–1–B, these differences are pointed out in this section. Each terminal includes a transmitting and a receiving branch for each channel, and a common transmitting and a common receiving branch through which all four channels pass. Channel 1 utilizes the voice frequencies, and channels 2, 3, and 4 utilize carrier frequencies for transmission over the circuit.

139. Channel 1 Transmitting Branch

Figure 57 is a schematic diagram of the channel 1 transmitting and receiving branches of Telephone Terminal CF–1–A, and figure 58 is a schematic diagram of the channel 1 transmitting and receiving branch of Telephone Terminal CF–1–B.

a. Telephone Terminal CF–1–A. Speech currents arriving from the switchboard pass through the MEAS key, through the hybrid repeating coil H, through the SEND key, a 9-db pad, a repeating coil B, to voltage limiter V, and repeating coil A. The purpose of the voltage limiter is to prevent high speech volumes from overloading the common amplifier. This limiter utilizes shunt varistors which have the property of rapidly decreasing their resistance as the voltage applied to them increases above a predetermined value. This introduces loss to the peaks of speech of very loud

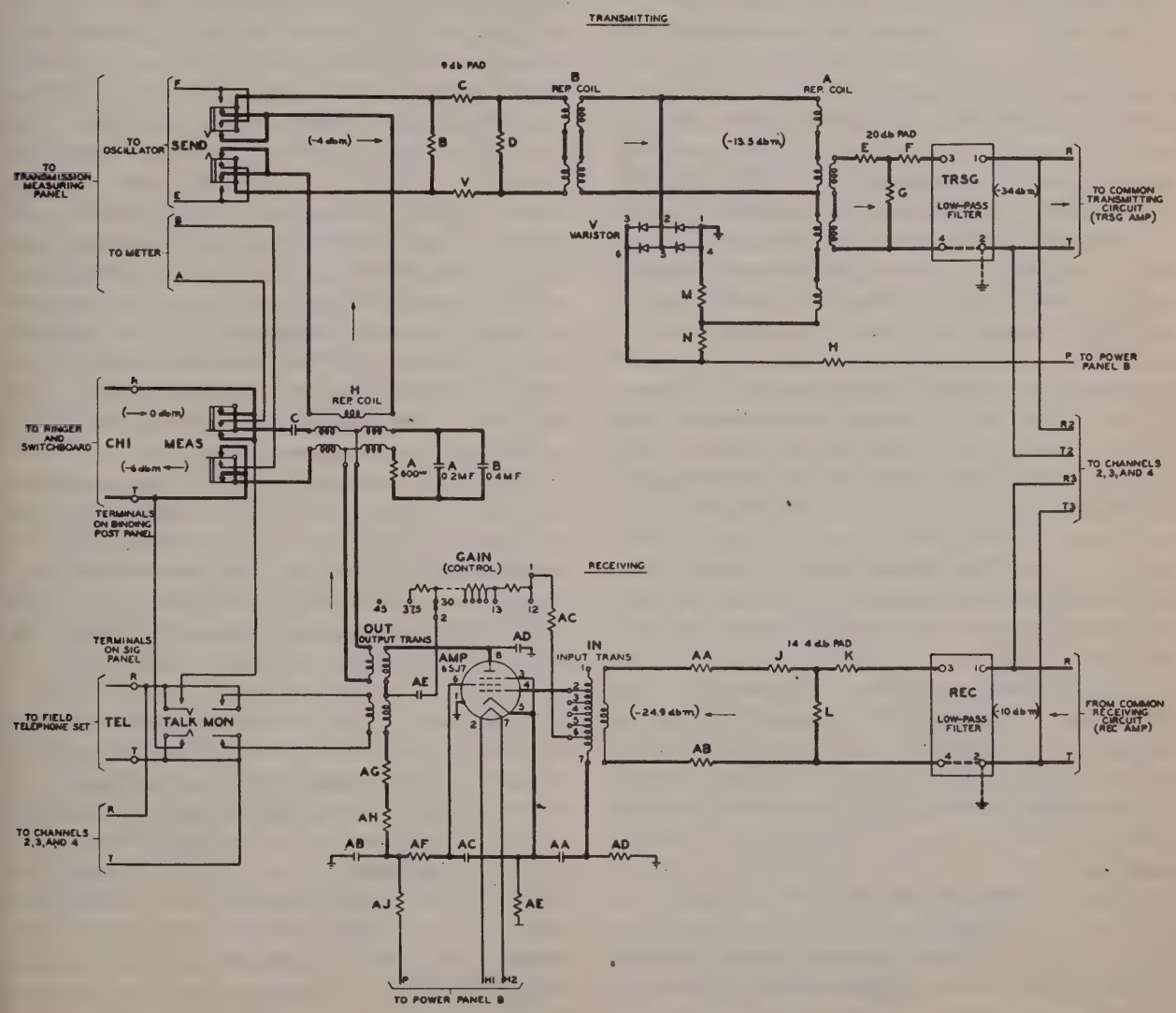

Figure 57. Telephone Terminal CF–1–A, channel 1 transmitting and receiving circuits, schematic diagram.

talkers. The output side of repeating coil A is connected to the common transmission circuit through a 20-db pad and the TRSG low-pass filter. The low-pass filter TRSG restricts the frequency band to about 2,800 cycles and prevents the high speech frequencies from causing interference in the adjacent channels. At the output of the low-pass filter TRSG, channel 1 is connected to the path common to all four channels for amplification by the common transmitting amplifier. The 20-db pad ahead of the low-pass filter reduces the power of channel 1 to the same level as that of the other three channels. The SEND key is arranged to connect testing power directly to channel 1. When operated, this key disconnects the transmitting branch from the hybrid coil H and connects 1,000-cycle testing power from the test oscillator to the transmitting branch. The amount of testing power (–4 dbm) is equivalent to applying a power of 0 dbm at the two-wire side of the hybrid coil H, 4 db being the loss through the hybrid coil.

b. Telephone Terminal CF–1–B. (1) Speech currents arriving on a two-wire or four-wire basis from the circuit terminal or from a connected carrier channel pass through the CHANNELS-2W OR 4W TRANSMITTING binding posts (CH1), capacitor C, hybrid repeating coil H, the SEND key of the measuring circuit, and a 9-db pad to repeating coil A. Repeating coil A has its windings arranged so that it has two sets of secondary windings. This arrangement eliminates repeating coil B which appears in Telephone Terminal CF–1–A. One set, winding 5–6, connects the transmission circuit through a 20-db pad and the TRSG low-pass filter to the common transmitting circuit. The TRSG filter passes frequencies below 2,800 cycles and suppresses all higher frequencies which might cause interference into the other channels. The 20-db pad reduces the power in channel 1 so that it will be the same as that of the other channels as they enter the common transmitting circuit. The SEND key is arranged to connect 1,000-cycle test power from the test oscillator into the circuit. The amount of testing power is —4 dbm which is equivalent to applying 0-dbm test power at the binding posts, the loss through hybrid coil H being 4 db.

(2) The second set of secondary windings of repeating coil A, made up of windings 3–4, 7–8, 9–10, and 11–12, is connected to a voltage-limiter circuit. This circuit introduces loss to the peaks of speech of very loud talkers. A voltage in the primary winding of coil A induces voltages in both secondary windings. As the applied voltages become larger due to a loud talker on the circuit, the impedance of varistor V becomes lower, lowering the impedance of the limiter circuit. A larger proportion of the speech energy is then induced into the limiter circuit and a lesser amount passes to the TRSG filter. The amount of energy which passes to the TRSG filter is regulated by the action of the limiter circuit. A d-c bias is placed on the limiter circuit, the amount of this bias determining the point at which the varistor V begins to act.

140. Channel 1 Receiving Branch

a. Telephone Terminal CF–1–A.

(1) The four channel bands are received from the common receiving circuit, and the low-pass filter REC selects the frequencies of channel 1 and rejects the frequencies of the other three channels. The 14.4-db pad provides the correct input to the input transformer IN, the output of which feeds the voice-frequency amplifier. The voice-frequency amplifier provides the gain necessary to obtain the desired circuit net loss, usually 6 db. From the amplifier the speech currents pass through the output transformer OUT to the hybrid repeating coil H, through this coil to the MEAS key, and to the switchboard or other connected equipment. The amplifier is a single-tube feedback amplifier using AMP tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT) and having a minimum gain of 12 db and a maximum gain of 45 db. The gain of the amplifier is indicated by the setting of the GAIN potentiometer and is adjustable in 1-db steps from 12-db to 30-db gain. Steps 37.5 and 45 provide gains of approximately 37.5 and 45 db respectively. Operation of the MEAS key terminates the channel in the transmission measuring meter for measuring the testing power received over channel 1.

(2) At the time of the over-all system line-up, and subsequently as required in maintaining the channel output, the GAIN potentiometer is adjusted until the specified output of the two-wire line is obtained. For a —6-db output the normal setting will be about step 21. The channel terminates in binding posts designated CH1 (2W). The TALK-MON key is arranged to connect the channel circuit to the TEL binding posts located on the signal panel to which a field telephone set is connected.

b. Telephone Terminal CF–1–B. (1) As in Telephone Terminal CF–1–A, the four channels are received from the common receiving circuit, and the low-pass filter REC selects the frequencies of channel 1 and rejects the frequencies of the other three channels. The 14.4-db pad provides the correct input to the input transformer IN, the output of which feeds the voice-frequency amplifier, and the amplifier furnishes the gain necessary to obtain the desired circuit net loss. The amplifier is the same as is used in Telephone Terminal CF–1–A in that it performs the same function and provides the same range of gain. The feedback circuit has been changed, however, so that two capacitors and three resistors are eliminated. The gain is indicated by the setting of the channel GAIN potentiometer.

(2) From the amplifier the speech currents pass through the output transformer OUT, the channel MEAS key, to the CHAN 1 2 WIRE-4 WIRE CHANNEL TERMINATION key. When the key is operated to the 2 WIRE position, speech currents pass through the key and the hybrid repeating coil H to the CHANNELS-2W OR 4W TRANSMITTING binding posts (CH1) and to the switchboard or other connected equipment. When the key is operated to the 4 WIRE position the hybrid coil is disconnected from the receiving circuit and is terminated in 300-ohm resistor N1. In this case speech currents pass through the key, through two 150-ohm resistors T1 and R1, to the CHANNELS-4W RECEIVING binding posts (CH1) and to the equipment connected to the channel on a four-wire basis. The T1 and R1 resistors are inserted to give a 600-ohm impedance termination to the circuit and also to provide an output power at the CHANNELS-4W RECEIVING binding posts (CH1) equivalent to that which would be obtained at the CHANNELS-2W OR 4W TRANSMITTING binding posts (CH1) if the channel were terminated on a two-wire basis. Thus a given setting of the GAIN potentiometer provides approximately the same value of circuit net loss whether a two-wire or four-wire termination is used. Operation of the MEAS key disconnects the channel termination and terminates the channel in the transmission measuring circuit for measuring the test power over channel 1.

(3) In maintaining channel output, the GAIN potentiometer is adjusted until the required channel output is obtained. For a −6-db output (6-db net loss) the normal setting of the GAIN potentiometer is about step 21. This GAIN setting is independent of whether the channel is terminated on a two-wire or four-wire basis. When terminated on a two-wire basis, the channel terminates on the CHANNELS-2W OR 4W TRANSMITTING binding posts (CH1). When the channel is terminated on a four-wire basis, the transmitting branch terminates in the CHANNELS-2W OR 4W TRANSMITTING binding posts (CH1) and the receiving branch terminates in the CHANNELS-4W RECEIVING binding posts (CH1).

141. Channels 2, 3, and 4

Channels 2, 3, and 4 differ from channel 1 on Telephone Terminals CF–1–A and CF–1–B since the speech currents are shifted by modulation for transmission over the cable and require demodulation at the receiving terminal to convert the carrier-frequency band back to voice frequency. Figure 22 is a front view of a channel 2, 3, or 4 panel of Telephone Terminal CF–1–A, and figure 59 is a schematic diagram of the channel 2, 3, or 4 transmitting and receiving circuits of Telephone Terminal CF–1–A. Figure 60 is a schematic diagram of the channel 2, 3, or 4 transmitting and receiving circuits of Telephone Terminal CF–1–B. These channels of Telephone Terminals CF–1–A and CF–1–B are alike in themselves except for the values of the oscillator tuning capacitor E, the pad formed by resistors E, F, and G, and the frequency bands passed by the TRSG 2 and REC 1 filters. Since the transmission loss through the TRSG 2 filters varies somewhat for the three channels, the loss of the associated pad formed by resistors E, F, and G is chosen so that the loss of the filter and pad is 12.5 db for each channel.

142. Channels 2, 3, and 4 Transmitting Branches

a. In the transmitting branches of Telephone Terminals CF–1–A and CF–1–B, a carrier supply oscillator for each channel provides a carrier frequency which, when combined with the voice frequencies in the modulator, results in the production of the upper and lower side-band frequencies shown in table XXVI. The upper sidebands are suppressed by the band-pass filters, and the lower sidebands enter the transmitting circuit which is common to all four channels. These lower sidebands and the channel 1 band are then amplified by the common transmitting amplifier before entering the cable. The pad associated with the TRSG 2 filter in each transmitting circuit reduces the power in each channel to a common value at the input to the transmitting amplifier.

Table XXVI.—Frequency ranges

Channel No.	Carrier oscillator frequency (cycles)	Lower sideband (used) (cycles)	Upper sideband (suppressed) (cycles)
2	5, 900	3, 100– 5, 700	6, 100– 8, 700
3	8, 850	6, 050– 8, 650	9, 050–11, 650
4	11, 800	9, 000–11, 600	12, 000–14, 000

The modulator TR consists of copper-oxide varistor elements arranged in a balanced circuit that suppresses the carrier frequency, voice frequencies, and extraneous products of modulation from its output. The oscillator which supplies carrier frequency to the modulator uses the OSC Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT), and also supplies the carrier frequency for the demodulator in the receiving circuit. The oscillator frequency is determined by a tuned circuit consisting of a coil C and a capacitor E which are preadjusted during manufacture. A fine adjustment of frequency is available by changing the position of a permalloy plug associated with the oscillator coil C. The modulator provides approximately the same amount of limiting control as the voltage limiter of channel 1.

b. Occasionally the frequency of the oscillator may have to be adjusted to maintain synchronism between the channel oscillators at the two terminals of the system. If the frequency of the two oscillators differs by more than 25 cycles, the natural quality of speech transmitted over the system may be impaired. Also, errors may be introduced into voice-frequency telegraph circuits which may be operated over the system. Maintaining synchronism between terminals within these limits is particularly important. Oscillator

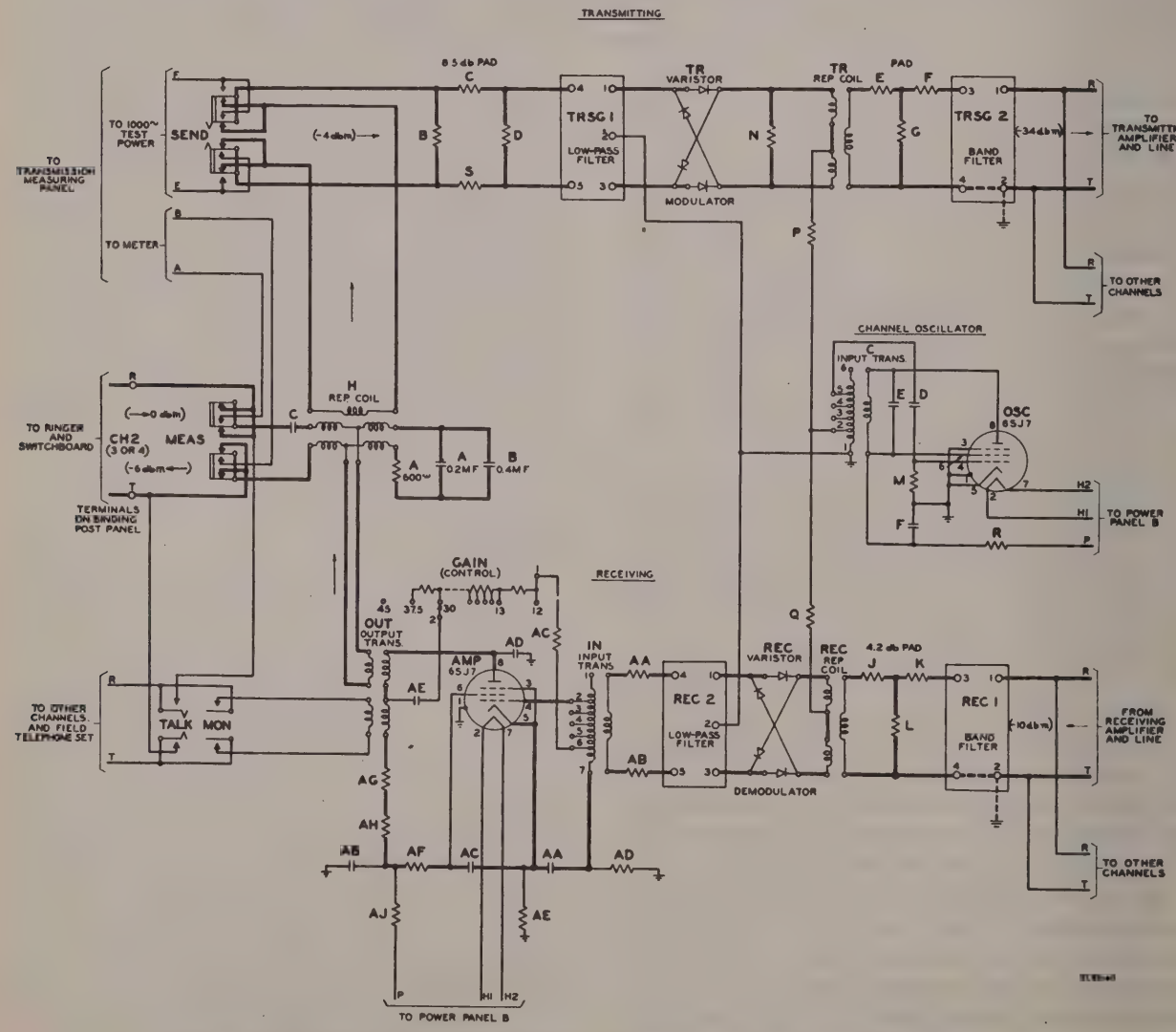

Figure 59. Telephone Terminal CF–1–A, channel 2, 3, or 4 transmitting and receiving circuits, schematic diagram.

coil C is equipped with an adjustable permalloy plug. Fine adjustments of frequency may be made by adjusting the position of this plug.

c. Speech currents arriving from the switchboard and the terminal binding posts in the case of Telephone Terminal CF–1–A and from the terminal binding posts in the case of Telephone Terminal CF–1–B pass through the MEAS key, the hybrid repeating coil H, through the SEND key to an 8.5-db pad, and through a low-pass filter TRSG 1 which restricts the voice currents to a band below 2,800 cycles. From the filter TRSG 1 the currents go to the TR varistor modulator which changes the voice frequency into selected carrier frequency for transmission, then to the TR repeating coil and the E, F, and G pad to the band-pass filter TRSG 2. This filter, in conjunction with low-pass filter TRSG 1, prevents the frequencies of one channel from overlapping those of another channel.

143. Channels 2, 3, and 4 Receiving Branches

a. Telephone Terminal CF–1–A. (1) The four bands of frequencies received from the common receiving branch are separated by the band-pass filter REC 1, and the proper frequency bands for channels 2, 3, and 4 enter their respective branches. The receiving filter REC 1 is a band-pass filter and is of the same type as the TRSG 2 filter used in the corresponding transmitting circuit TRSG 2. The filter in each channel selects the required channel band and rejects all others. The frequency band selected is attenuated by a 4.2-db pad and is applied through the repeating coil REC to a demodulator REC which is supplied with a carrier frequency of the same frequency as that used at the transmitting terminal. As the result of the demodulation two sidebands are produced, one of which is the original voice-frequency band. The demodulator is similar to the modulator in arrangement and functions. The low-pass filter REC 2 in each channel suppresses the unwanted sideband and carrier frequency.

(2) After demodulation the speech energies pass through the input transformer IN to the voice-frequency amplifier which is identical to that of channel 1, through the output transformer OUT, through the hybrid repeating coil H, and to the switchboard. The voice frequencies are amplified to give the proper output at the two-wire side of the hybrid repeating coil H. The GAIN potentiometer is used to control the amount of amplification in the same way as in channel 1. The SEND and MEAS keys perform the same function as for channel 1. These keys on channel 3 are provided with guards to prevent accidental operation which would cause interruption to voice-frequency telegraph circuits, normally used on channel 3. Channels 2, 3, and 4 terminate on binding posts designated CH2, CH3, and CH4. The TALK-MON key connects channel 2, 3, or 4 to the field telephone set in the same way as for channel 1. This key on channel 3 is also equipped with a guard to prevent accidental operation.

b. Telephone Terminal CF–1–B. (1) The four bands of frequencies received from the common receiving branch are separated by the channel band-pass filter REC 1, and the frequency bands of channel 2, 3, or 4 enter their respective branches. The filter REC 1 is a band-pass filter of the same type as filter TRSG 2 used in the corresponding transmitting circuit. After passing through the REC 1 filter, the channel bands are attenuated by the 4.2-db pad to the proper value to enter the demodulator circuit. The demodulator circuit consists of repeating coil REC, demodulator varistor REC, and an output coil which is included as part of the low-pass filter REC 2. This circuit functions in the same manner as the channel modulator circuit. After the channel band passes through the demodulator circuit, two frequency bands are produced. One of these is the original voice band. Low-pass filter REC 2 passes the voice band and rejects the other sideband and carrier frequency.

(2) After demodulation the voice frequencies pass through the input transformer IN to the voice-frequency amplifier. This consists of the input transformer IN, vacuum tube AMP, and output transformer OUT. The amplifier is identical to that of channel 1. From the amplifier the voice frequencies pass to the channel MEAS key, and from there to the channel 2 WIRE–4 WIRE key. From this point two paths may be taken, depending upon whether the channel is terminated on a two-wire or four-wire basis. The channel terminating arrangements are the same as for channel 1.

(3) Two 4-db pads are mounted in the rear of the binding post panel and are wired to binding posts on the front of the panel. These are designated 4 DB PAD NO. 1 and 4 DB PAD NO. 2. They are used under some conditions when a channel is terminated on a four-wire basis. They may be inserted between the CHANNELS-4W RECEIVING binding posts of any channel and the connecting telephone or telegraph equipment

to provide the required input to that equipment when the input is below the range of the channel GAIN potentiometer, or they may be inserted between CHANNELS-2W OR 4W TRANSMITTING binding posts and the connecting equipment to lower the input to any channel to the proper input value of 0 dbm.

144. Common Transmitting and Receiving Circuits

The common transmitting and receiving branches of Telephone Terminals CF–1–A and CF–1–B are identical. However, the binding post panel of Telephone Terminal CF–1–B differs from that of Telephone Terminal CF–1–A. (See figs. 15 and 16.) Figure 61 is a schematic diagram showing the common transmitting branch and the common receiving branch of Telephone Terminal CF–1–(*) through which the four bands of frequencies of channels 1, 2, 3, and 4 pass. Figure 18 is a front view of the line amplifier panel of Telephone Terminals CF–1–(*).

145. Common Transmitting Branch

a. The four bands of frequencies transmitted from channels 1, 2, 3, and 4 pass through a pad having values of 16, 11, or 6 db, depending upon the position of the OUTPUT key, through the common transmitting amplifier TRSG, and to the cable circuit. The values of the key-controlled pads are such that when the specified test power is applied, the power delivered to the cable may be 0, +5, or +10 dbm. The 0-dbm output is obtained with the OUTPUT key in the NORMAL position. This OUTPUT key also controls the pads in the transmission measuring circuit to facilitate measuring the power delivered to the cable for the three settings of the key. The OUTPUT key is equipped with a guard to prevent accidental operation. It may be used to lock the key in any of its three positions.

b. The transmitting amplifier is a two-stage feedback amplifier having a gain of about 50 db over the band from 200 to 12,000 cycles. The key-controlled pad introduces losses of 16, 11, or 6 db to reduce the over-all gain of the common transmitting branch to 34, 39, or 44 db to deliver power to the line of 0, +5, or +10 dbm when a testing power of 0 dbm is applied to the two-wire side of any channel. Telephone Terminals CF–1–A bearing serial numbers below 517 are not equipped with the OUTPUT key and a fixed pad of 16 db is used, giving an output of 0 dbm to the cable circuit. In the amplifier, tube V1 (6SJ7 or 6SJ7GT) is Signal Corps Tube VT–116 or VT–116–A, and tube V2 (6V6GT) is Signal Corps Tube VT–107–A. The amplifier gain will change only slightly with changes in supply voltages, tubes, and temperature due to the use of the feedback principle.

c. The output of the transmitting amplifier is connected to the cable through an inequality ratio repeating coil T with capacitors A and B bridged across its winding to provide a good impedance termination for the loaded cable. The circuit terminates on binding posts marked TRSG, T and R. The white pairs of Cable Stub CC–356 are connected to these binding posts. The white pair is connected to the female terminals of the associated cable stub connector. The shield wire of the cable stub is connected to the SH binding post, which in turn is connected internally to ground. The simplex circuit is taken off the midpoint of the cable side winding of repeating coil T and terminates on a binding post designated SX TRSG.

d. The carrier equipment is protected against excessive external potentials by protector blocks (open space cut-outs) TRSG, T and R. These external potentials may be due to lightning surges or power surges from nearby power lines. One winding of a two-winding coil DT is connected between each protector and ground. The high impedance of the coil at voice and carrier frequencies prevents a momentary shorting of the circuit when the protectors are operated. Such shorting would cause errors in the telegraph circuits which may operate over channel 3. The protectors consist of WECo No. 26 and No. 27 protector blocks which, when clean, have an air gap which will break down when a potential greater than about 300 volts is applied. After repeated break-downs of the protectors the gap may become filled with carbon, thus diminishing the gap. This will cause the protectors to break down on smaller potentials and may cause excessive noise in the channels, or they may become grounded and require cleaning. The protector blocks are mounted at the upper left front of the bay and are readily accessible. They may be cleaned by rubbing the flat surfaces of two blocks together or by rubbing with a fine abrasive cloth.

146. Common Receiving Branch

a. Connection from the incoming cable pair is made to the common receiving circuit at the REC binding posts over the colored pair of the cable

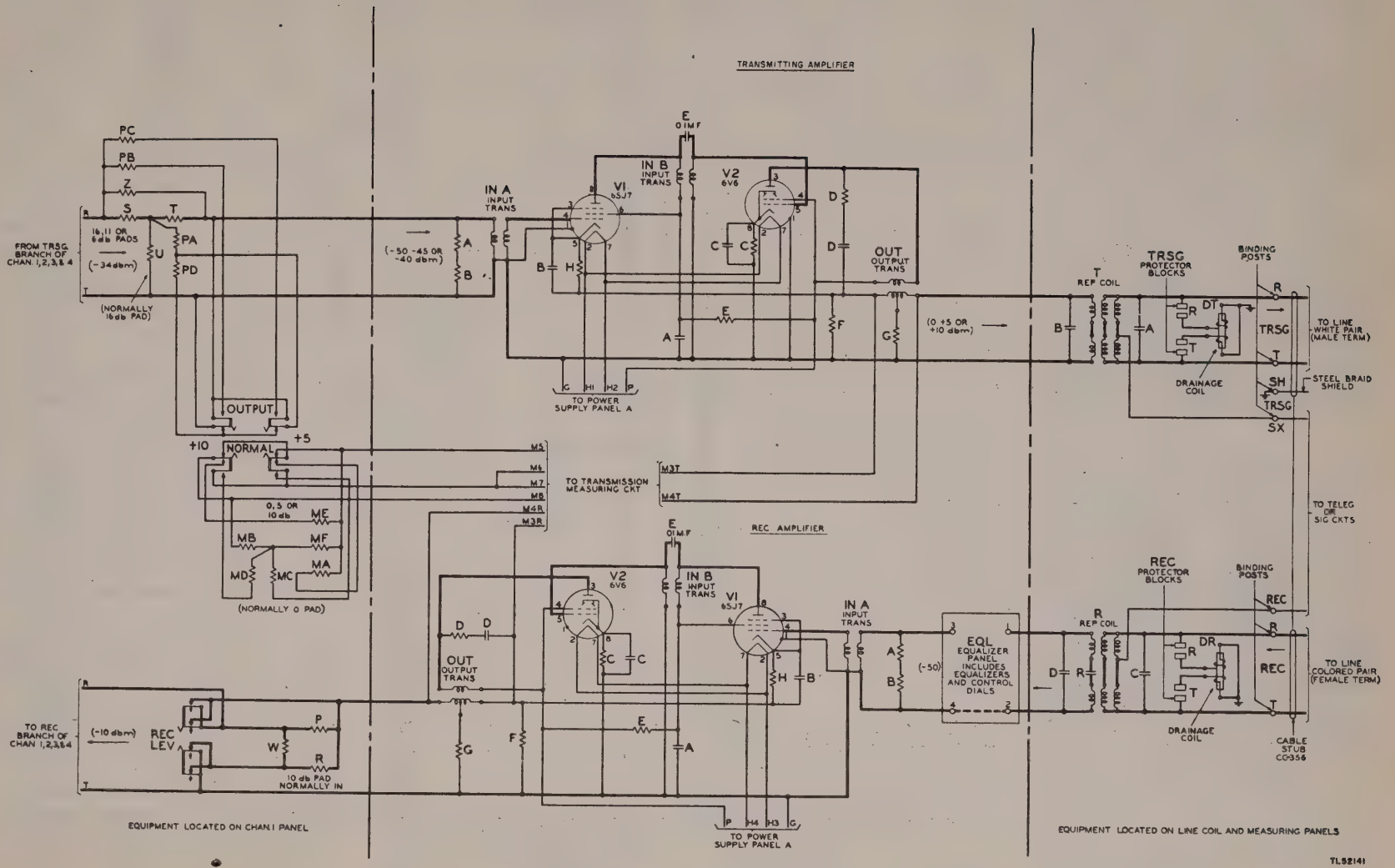

Figure 61. Common transmitting and receiving circuit, schematic diagram.

stub. The colored pair is connected to the male terminals of the associated cable stub connector. The arrangement of the protectors REC, T and R and coil DR is similar to that of the transmitting branch. The simplex leg of the incoming cable pair from REP COIL R terminates on a binding post SX REC.

b. The four channel bands have frequencies that arrive at the receiving terminal from the adjacent repeater or from the distant terminal. These are attenuated by the loss of the preceding cable section and must be amplified in the common receiving circuit. The loss of the cable changes with frequency, so that the amount of gain required depends not only on the length of the cable section and the temperature, but on the frequency as well. To provide a gain control which can be varied as required, a fixed gain amplifier preceded by an equalizer EQL, consisting of four adjustable networks, is used. One dial is provided for each network.

c. The method by which the gain adjustment is made is illustrated in figure 62. Assume that the dials are set to permit about equal gain at all frequencies. For a 25-mile section of cable at 70° F, the output of the receiving amplifier would

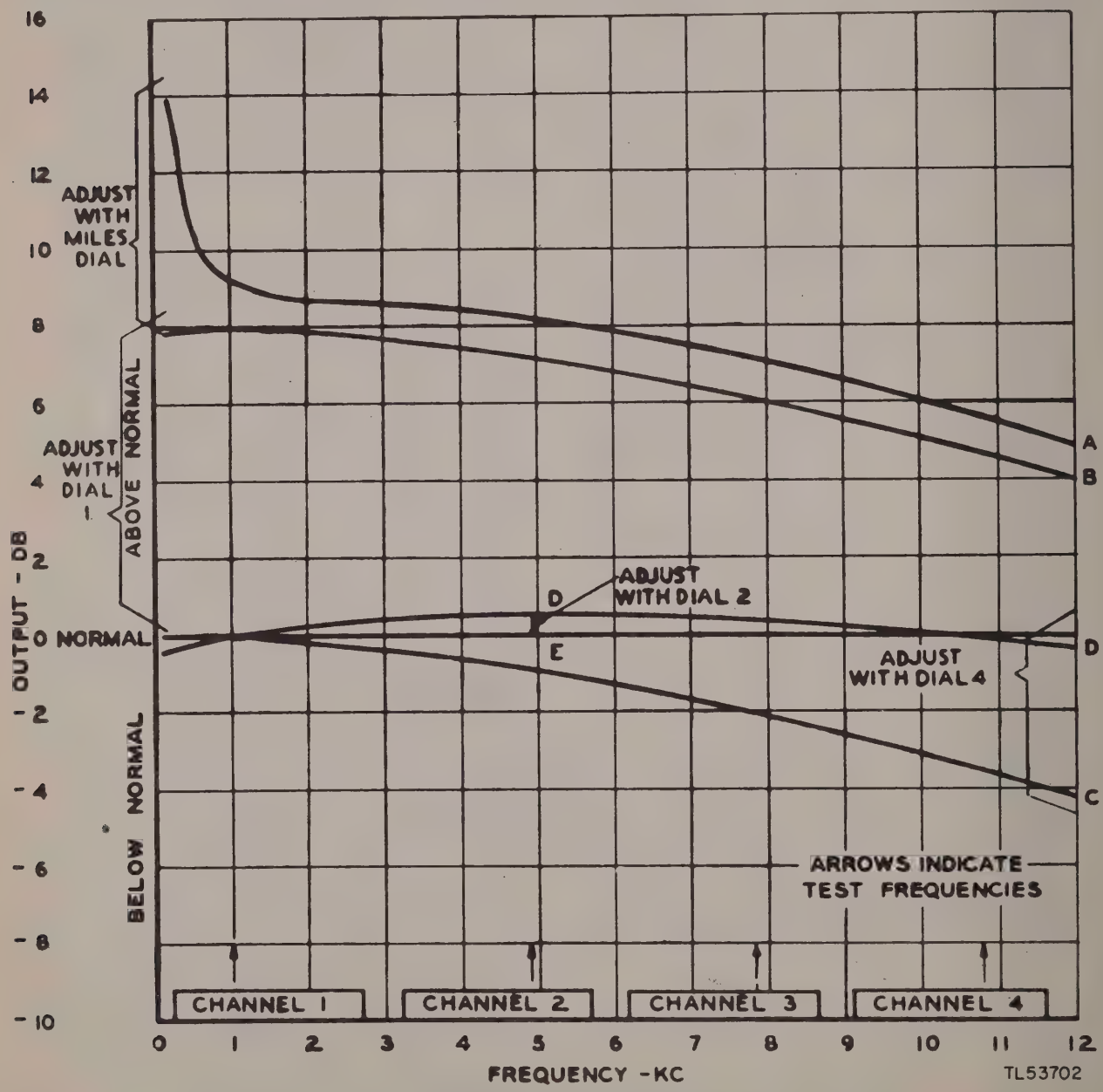

Figure 62. Gain adjustment.

then be shown as curve A. The excess gain at frequencies below 1,000 cycles is reduced by adjusting the low-frequency network in accordance with the length of the preceding cable section, which in this case is 25 miles. The resulting characteristic is shown on curve B. The gain at 1,000 cycles (the testing frequency for channel 1) is then set to give a normal output of 0 dbm by adjusting the flat gain network which changes the gain equally at all frequencies. The resulting characteristic curve is shown on curve C. There is now a deficiency of gain at the higher frequencies which is corrected by adjusting the high-frequency network to deliver the normal output at 10,800 cycles (the test frequency of channel 4). This adjustment results in the characteristic about as shown in curve D. Under certain conditions, the power output at frequencies between 1,000 and 10,800 cycles may be either too high or too low after the above adjustments have been made because the variations in cable characteristics deviate from a straight line. To take care of these cases, a midfrequency network is provided to change the gain at the intermediate frequencies. This adjustment is made using a 1,000-cycle test tone on channel 2, and results in a

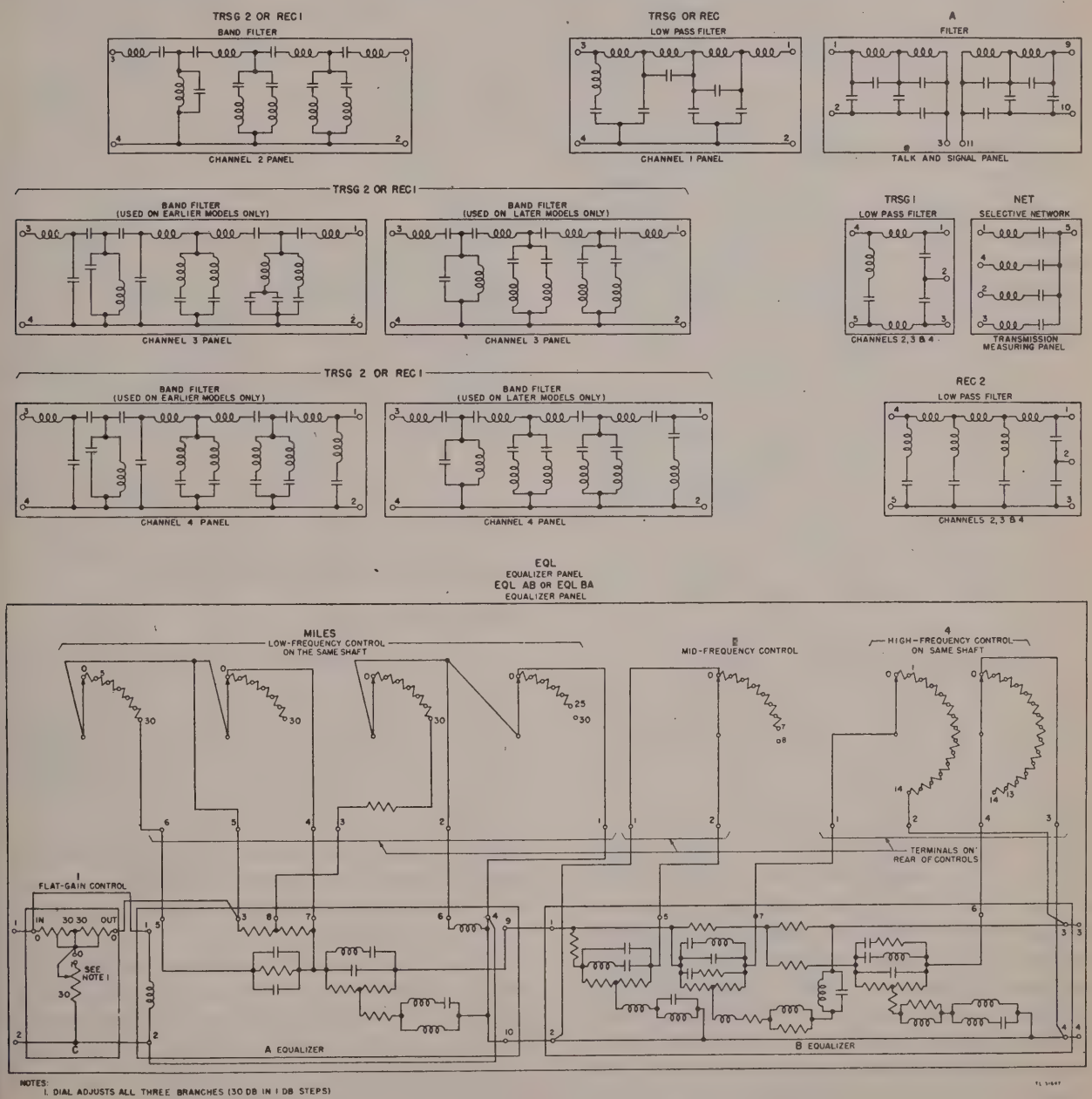

Figure 63. Internal wiring of filters and equalizing equipment.

characteristic as shown in curve E. The adjustments made with test power on channels 1, 4, and 2 give the correct output of channel 3. If necessary, channel 3 can replace channel 2 for the adjustment of the midfrequency network. The arrows in figure 62 show the location of the test frequencies.

d. The adjustable networks and their control dials are located on the equalizer panel, a front view of which is shown in figure 19. The low-frequency network is controlled by the MILES dial, and is adjustable in 5-mile steps up to 30 miles. The flat gain network is controlled by dial 1, and is adjustable in 1-db steps from 0 to 30 db. The high-frequency network is controlled by dial 4, and is adjustable in 1-db steps from 0 to 14 db. The midfrequency network is controlled by dial 2, and is adjustable in 1-db steps over a range of plus or minus 4 db. The zero position of this network for additional gain or loss at the midfrequencies is step 4. The dials controlling the flat, high-frequency, and midfrequency networks are designated in accordance with the channel on which test power is measured when making the adjustment. A chart indicating the approximate settings of the dials for various line section lengths is mounted on the equalizer panel as shown in figure 19. Space is provided on the chart for writing in the operating dial settings. Minor adjustments of the equalizer may be made while the system is in service without following the complete outline given above. When checking the line-up in practice, however, it is advisable to check the channel 1 transmission before making changes in adjustments of dials 4 or 2, since changes in adjustments of dial 1 changes the transmission of all channels.

e. The receiving amplifier circuit is identical with that of the transmitting amplifier. It has a fixed gain of 50 db. A 10-db pad, which is normally in the circuit, is arranged so that it may be removed by operation of the REC LEV key located on the channel 1 panel to afford 10-db additional gain. This may be useful in maintaining service in the case of trouble in the line which results in the power being abnormally low. A guard is placed on the REC LEV key to lock it in place and to prevent false operation. This guard may be used to lock the key in either its normal or its operated position. In some cases this pad in conjunction with the pad at the transmitting terminal, may be used to extend the distance between terminals if noise conditions permit. The output of the 10-db pad is connected to the channel filters which select the individual channel frequencies. The four bands of frequencies for channels 1, 2, 3, and 4 now pass to the channel receiving branches and each band is selected by the proper branch.

147. Vacuum Tubes

Two types of vacuum tubes are used in Telephone Terminals CF–1–A and CF–1–B as shown in table XXVII.

Table XXVII.—Vacuum tubes used in telephone terminals CF–1–A and CF–1–B

Equipment	Quantity of Tubes VT–116 or VT–116–A (6SJ7 or 6SJ7GT)	Quantity of Tubes VT–107–A (6V6GT)
Channel oscillators	3	
Channel amplifiers	4	
Common amplifiers	2	2
1,000-cycle oscillator	1	
Total	10	2

Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT) is a pentode, while Tube VT–107–A (6V6GT) is a beam-power amplifier. Tube VG–116 (6SJ7) is metal and should be used when available, otherwise Tube VT–116–A (6SJ7GT), which is glass, may be used. The operating voltages required by the tubes are 6.3 volts for the filament and 150 volts for the screen and plate. Cathode bias is used. A panel mounting eight sockets is provided for carrying spare tubes for the channel panels and measuring circuit. A complete set of spare tubes for the transmitting and receiving amplifiers is mounted on the line amplifier panel.

148. Power Supply

The operating voltages for the telephone terminals are derived from two power supply panels located at the bottom of the terminal bay. Two identical supply circuits are provided: PWR SUP A supplies the transmitting and receiving amplifiers and the signal and alarm circuit, and PWR SUP B supplies the channel and measuring circuits. Front and rear views of the power supply panel with the covers removed are shown in figures 26, 27, and 66. Figures 64 and 65 are schematic diagrams of power supply panels.

a. Each power supply panel operates from 115-volt or 230-volt, 50- to 60-cycle, a-c supply, or from a 12-volt storage battery. The external a-c power is applied to the primary windings of transformers T and T1. They are normally connected for 110 to 125 volts, but may be recon-

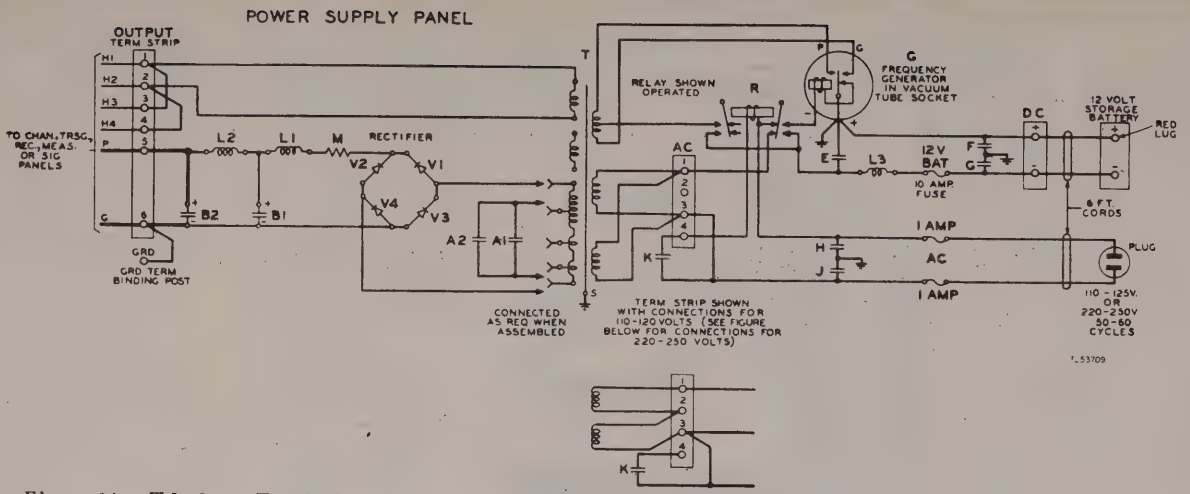

Figure 64. Telephone Terminal CF–1–A (serial numbers below 380) and Repeater CF–3–A (serial numbers below 723), power supply panel, schematic diagram.

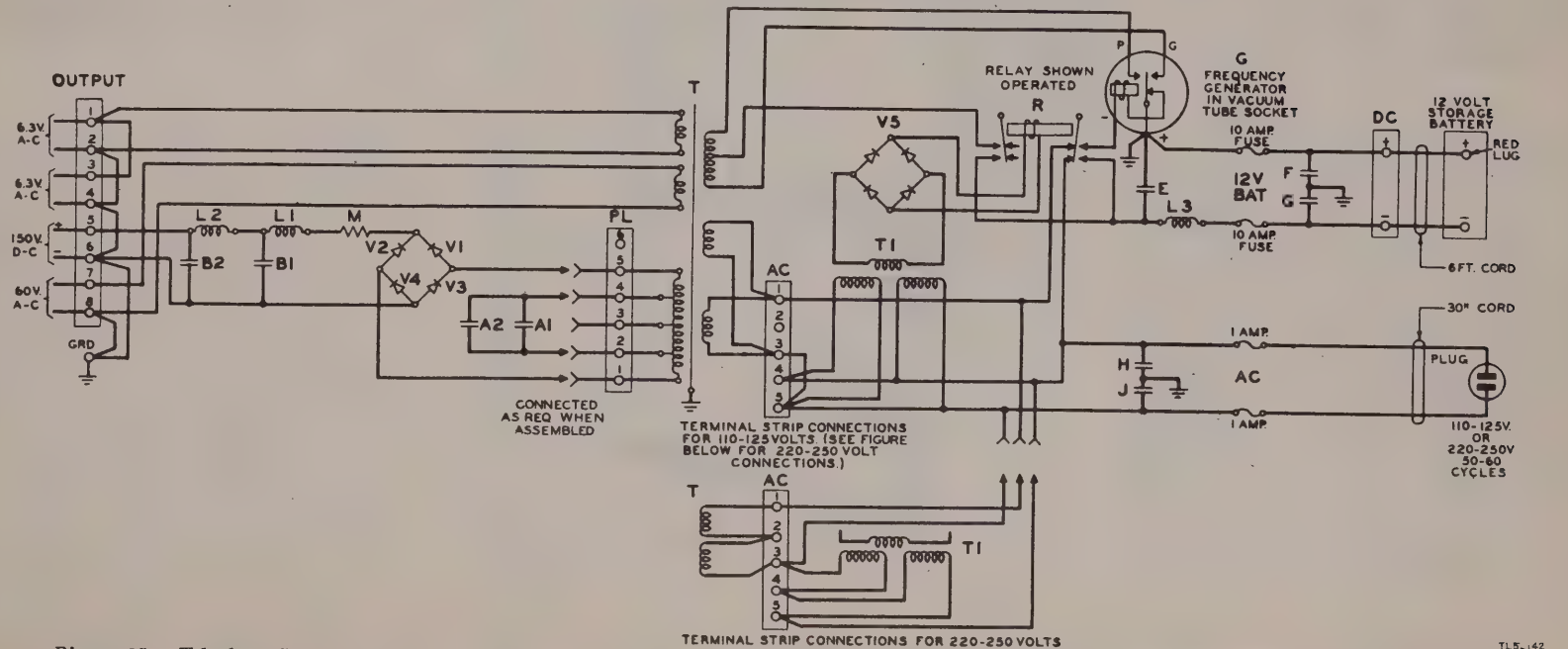

Figure 65. Telephone Terminals CF–1–A (serial numbers 380 and higher) and CF–1–B and Repeater CF–3–A (serial numbers 723 and higher), power supply panel, schematic diagram.

nected to operate on 220 to 250 volts by changing the connections to the top terminal strip AC provided for this purpose. (See figs. 26 and 27.) Several windings are provided on the secondary transformer T for supplying different voltages. The 6.3-volt winding supplies power for the tube filaments. The 60-volt winding supplies power for the signal bell. The 200-volt winding is connected to full-wave selenium disk rectifiers V1, V2, V3, and V4 which provide 150 volts direct current for the plates and screens of the vacuum tubes. Coils L1 and L2 and capacitors B1 and

of 110 to 125 volts or 220 to 250 volts, it will be possible to operate with only minor degradation over some additional range in the order of 5 volts (105 to 130 or 210 to 260 volts) if it is found necessary. Some reduction in tube life may result, however, if operation at the reduced voltage is continued for an appreciable time.

b. Each power supply circuit includes a 60-cycle vibrator G operating from a 12-volt storage battery which supplies the operating voltages when the a-c supply is interrupted. The transfer in models with serial numbers higher than 516 is controlled

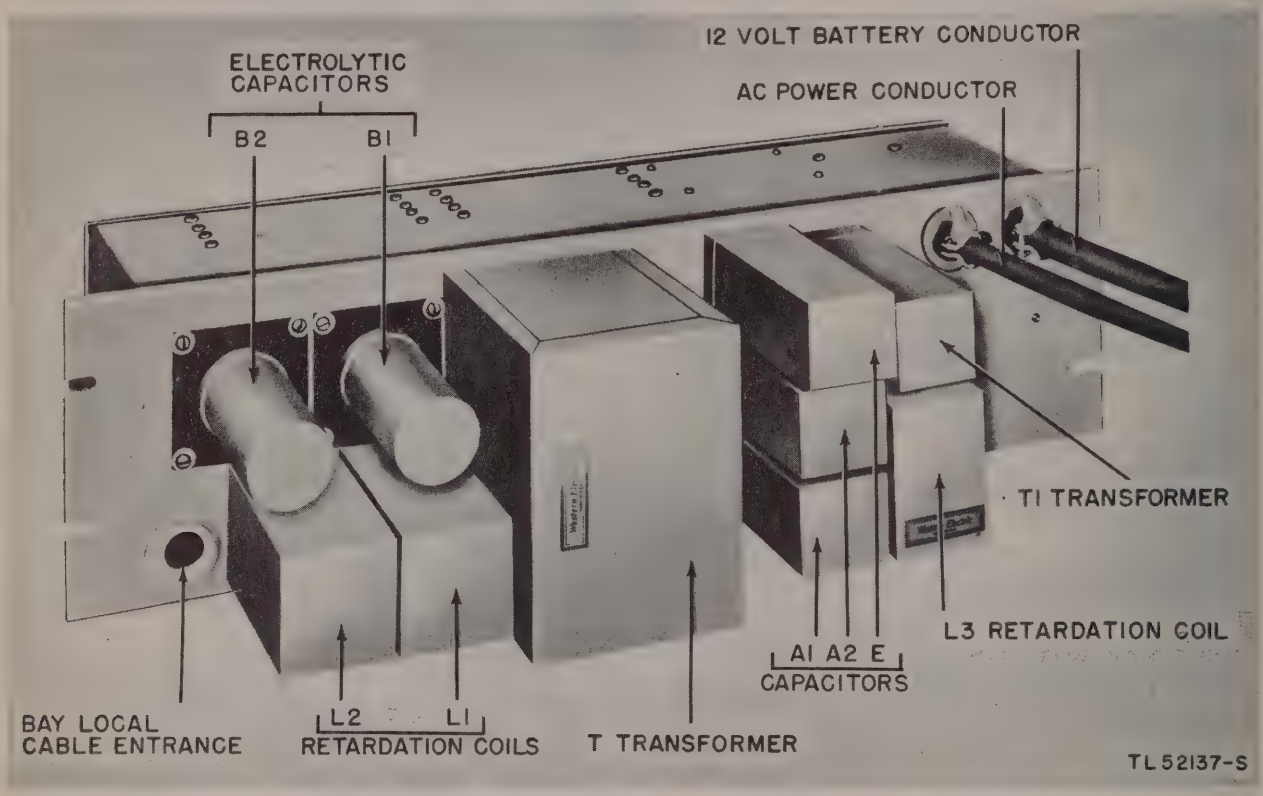

Figure 66. Telephone Terminal CF–1–A (serial numbers 380 and higher) and Telephone Terminal CF–1–B, power supply panel, rear view, cover removed.

B2 provide filtering for the 150-volt output. Capacitors H and J and capacitors F and G prevent high-frequency interference from the system to the power supply circuit. The 6.3-, 60-, and 150-volt outputs are wired to terminals on the OUTPUT terminal block of the power supply unit, from which connections are made to the individual tube and alarm circuits. One side of each of the 6.3- and 60-volt a-c supply terminals and the negative side of the 150-volt output are connected internally to the binding post GRD. While the carrier equipment, including the power supply panels, has been designed for normal operation on external power supply voltage variations

by a relay R which is normally held operated by direct current supplied from the varistor rectifier V5. This rectifier is connected to the transformer T1. The primary windings of the transformer T1 are connected to the terminal block AC. The leads connecting to the top side of this terminal block are arranged to permit them to be changed for operation from either 110- to 125-volt or 220- to 250-volt, 50- to 60-cycle supply mains in the same manner as for the connections for the transformer T. When the a-c supply is interrupted, the normally operated relay releases and connects the 12-volt battery to the vibrator, which in turn is connected to a separate primary winding

on the power transformer. The voltages thus available at the secondary side of the transformer T1 are the same as for either the 115- or 230-volt a-c inputs. The vibrator G is mounted in a vacuum tube socket, and a spare vibrator is provided on the power supply panel for quick replacement. Operation on the 12-volt battery is indicated by the audible hum of the vibrator. The battery drain for each supply panel is about 3.75 amperes.

c. A 30-inch cord terminating in a plug is provided with each power supply panel for connections to multiple a-c supply outlets located at the base of the bay. Six outlets are provided. Two are for the two power panels. The other four are for convenience and may be used to supply a-c power to other units, such as ringers, from the same a-c supply. An 8-foot cord designated AC, terminated in a plug at one end and in the multiple outlets at the other, is provided to connect to the external a-c supply. Both sides of the a-c supply are provided with 1-ampere fuses. Two spare 1-ampere fuses are mounted on the inside of the front cover of the power supply panel.

d. A 6-foot cord designated 12V BAT and equipped with battery terminals is provided with each power supply circuit for connection to the storage batteries. The lug marked 12V+ is connected to the positive terminal of the battery and the lug marked 12V— to the negative terminal. Normally a separate 12-volt storage battery unit made up of two 6-volt batteries connected in series should be used for each power supply panel. Be careful to assure proper poling from the leads to the 12-volt battery, particularly when it is necessary to use one battery unit to supply more than one power supply panel. The positive 12-volt tap is grounded on the panel. The negative and positive leads from the 12-volt battery each have a 10-ampere fuse. Two spare 10-ampere fuses are mounted on the inside of the front cover of the power supply panel.

e. The power supply panels furnished with Telephone Terminals CF–1–A bearing serial numbers higher than 380 differ from those of earlier models in the following respects:

(1) Transformer T1 and rectifier V5 have been added and the relay R operates from the rectified direct current supplied by the rectifier instead of directly from the a-c line as in the early models.

(2) Terminal arrangement of the AC terminal strip is changed to facilitate changing connections from 115-volt to 230-volt, 50-60-cycle a-c supply for both the transformers T and T1.

(3) The connections from the winding of transformer T to terminals 7 and 8 on the OUTPUT terminal strip have been added to furnish a 60-volt a-c supply for operating the bell of the signal circuit.

(4) A 10-ampere fuse is added in late models so that both leads to the 12-volt battery are fused. Figure 27 is a front view of the power supply panel of the models of Telephone Terminal CF–1–A with serial numbers 380 and above with the cover removed.

149. Functioning of Repeater CF–3–A

Repeater CF–3–A is composed of two independent amplifying circuits, one of which is associated with the A to B direction of transmission and the other with the B to A direction. A schematic diagram of the carrier repeater is shown in figures 92 or 94.

a. Circuit. An amplifier, a gain adjusting equalizer, and two repeating coils with simplex taps are provided in each direction of transmission. Drainage coils and line protectors are provided in each direction of transmission on both sides of the repeater. These units are identical with and function in the same manner as those used in the common receiving circuit at the terminal. (See fig. 61.) These circuits are terminated in binding posts for connection to Cable Stub CC–356.

(1) The gain adjustments at a repeater are made in the same manner as in the common receiving circuit at a terminal. The low-frequency network is set in accordance with the length of the preceding cable section. With the 1,000-cycle testing power being transmitted over channel 1, the flat gain control dial is adjusted until a 0-dbm output is obtained. Similarly, gain dials 4 and 2 are adjusted with test power on channels 4 and 2 in that order. (See fig. 62). This results in an output of 0-dbm for all four channels. A chart mounted on each equalizer panel indicates the approximate dial settings for various lengths of line. Space is provided on the charts for writing in the operating dial settings.

(2) The cable stubs are connected to the equipment at the binding posts located at the top of the repeater unit and shown in figure 28. For the A to B direction of transmission, the colored input cable stub pair is connected to the AB IN binding posts and the white output cable stub pair is connected to the AB OUT binding posts. The simplex taps are designated SC AB IN and SX AB OUT respectively. In the B to A direction, the colored input cable stub pair connects to the

BA IN binding posts and the white output cable stub pair to the BA OUT binding posts. The simplex taps are designated SX BA IN and SX BA OUT. The ground terminals for the cable shields are designated SH.

b. Vacuum Tubes and Power Supply. (1) Each amplifier uses one Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT) and one Tube VT–107–A (6V6GT) operating at the same voltages as the tubes in the terminal amplifiers. A complete set of spare tubes is mounted in the sockets on the amplifier panel.

(2) The power supply and grounding arrangements are the same as those provided at the terminal except that only one power supply panel is used. The a-c power required is 30 watts, and the drain from the 12-volt battery during emergency operation is 3.75 amperes.

150. Intercommunication Facilities at Terminals and Repeaters

Communication between terminals and intermediate repeater points is required in setting up the system and in making over-all system line-ups after it has been placed in service. An alarm and signaling circuit operating over one of the simplex circuits, together with arrangements for talking and monitoring over channel 1, are used for this purpose. The alarm and signaling circuit for Telephone Terminals CF–1–A and CF–1–B are identical. Figure 24 shows a front view of the signal panel at Telephone Terminal CF–1–A. Figure 25 shows a front view of the talk and signal panel at Telephone Terminal CF–1–B. Figure 29 is a front view of the talk and signal panel at Repeater CF–3–A. The talking and monitoring circuits of Telephone Terminals CF–1–A and CF–1–B differ. Telephone Terminal CF–1–A requires a field telephone set external to the equipment for talking and monitoring. Telephone Terminal CF–1–B has a built-in talking and monitoring circuit terminating in a hand-set, and the circuit is arranged to be used on channels terminated on either a two-wire or four-wire basis. At Repeater CF–3–A, a hand-set is permanently mounted on the bay for communicating over channel 1.

151. Alarm and Signaling Circuit

a. Figure 67 is a schematic diagram of the alarm and signaling circuit for a system having two terminals and two repeaters. Each terminal and each repeater is provided with alarm and signaling equipment arranged to be connected to one of the simplex circuits. Line relays, a SIGNAL key, a bell, and a SIGNAL CUT-OFF key are provided at each terminal and each repeater. At terminals there is a BATTERY-GROUND key for applying either battery or ground for the operation of the signal and alarm circuit. At each repeater a GROUND A-GROUND B key provides a ground termination on either side of the repeater when required. Grounded battery is applied to the circuit at terminal A by throwing the BATTERY-GROUND key to its BATTERY position.

b. From battery the circuit is carried through the lamp, BATTERY-GROUND key, the line relays, and the SIGNAL key to the simplex circuit of the line. The circuit then connects through the line relays and SIGNAL keys at the repeater points and terminal B, and terminates in ground at terminal B when the terminal B BATTERY-GROUND key is thrown to the GROUND position. This is a closed loop circuit and the relays are held operated unless the circuit is opened either by the operation of any of the SIGNAL keys or by an open in both of the line conductors. When the relay releases, the bells at all points will ring. Throwing the lever of the SIGNAL key at any point rings a bell at each terminal and intermediate repeater. If only one conductor is open, the simplex taps are still connected over one wire of the pair and the signals may not give an alarm even though transmission is badly affected. On the other hand, a grounded conductor on the pair used for the alarm and signal circuit or bad leakage to ground may cause the alarm and signaling circuit to become inoperative even though transmission over the carrier system is possible.

c. The alarm and signaling circuit is used for communication and maintenance or for indicating line failures. If a break occurs in the cable the bells will sound until silenced by the operation of the SIGNAL CUT-OFF keys. When the cable is again restored to operation, the bells again sound. They may be silenced by returning the SIGNAL CUT-OFF keys to their normal positions. If the cable is opened for an appreciable length of time, terminating the alarm and signaling circuit to ground at the repeaters on each side of the break will partially restore communication between repeaters and terminals. This is done by throwing the signaling circuit key lever at the repeater to the A or B position, depending upon the location of the repeater in relation to the break. If the break is toward terminal A, position A is used, and if toward terminal B, position B is

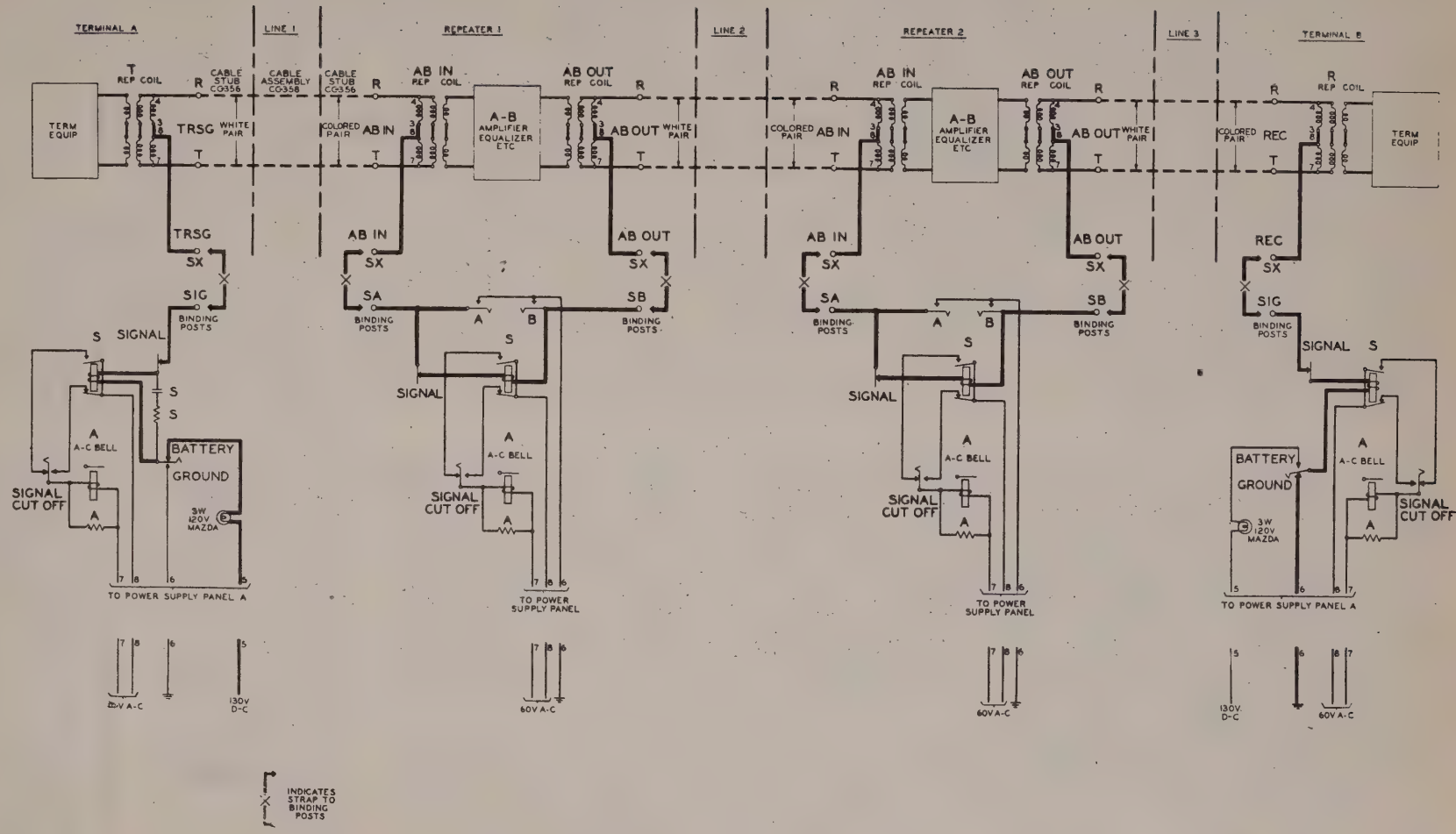

Figure 67. Alarm and signaling circuit of a system having two terminals and two repeaters, schematic diagram.

used. Battery for the section of the cable between the break and terminal B must be supplied at terminal B by throwing the key lever at terminal B to the BATTERY position. (See fig. 29.) If a failure occurs in the line section indicated as line 2, all bells will operate. By throwing the GROUND key lever at repeater 2 to position A and the key lever at repeater 1 to position B, the signaling circuit is terminated through the local signaling relays at both repeaters 1 and 2 to ground. The signaling circuit from terminal A to repeater 1 is now operative. If the key lever is thrown to the wrong position the through signaling circuit will be terminated to ground, but the local signaling circuit of the repeater at the point where the key is thrown will be left inoperative. With the key lever at terminal B thrown to BATTERY, a signaling circuit from terminal B to repeater 2 is provided. Signaling between the two line sections on either side of the break is not possible. When continuity of the line is reestablished in the line 2 section, the GROUND keys at repeater 1 and 2 must be restored to their normal positions and the key at terminal B must be restored to its GROUND position. The signal and alarm circuit then will function in its normal manner.

d. When setting up the signal and alarm circuit, straps are required between the simplex terminals of the line repeating coils and the signaling circuit terminals designated SIG at the terminals and SA and SB at the repeater points. These connections are shown in figure 28. The circuit may be operated over either of the simplex circuits provided by the cable by making suitable connections to the simplex terminals. Ordinarily the signaling circuit will be assigned to the cable pair associated with the A to B direction of transmission.

e. At a repeater point the alarm and signaling circuit terminates at two binding posts SA and SB. The SA binding post is connected to the cable toward terminal A and the SB binding post is connected to the cable towards terminal B. Front views of the binding post panels at terminals and a repeater are shown in figures 15, 16, and 28.

152. Talking and Monitoring Circuit

a. Telephone Terminal CF–1–A. For talking and monitoring at Telephone Terminal CF–1–A a field telephone set is connected to the TEL binding posts on the signal panel. Key arrangements on the channel panels (figs. 20 and 22) are for connecting the telephone set to any one of the four channels. When the TALK-MON key on the channel panel is operated to the MON position, the telephone set is connected to the monitoring winding of the channel amplifier, and the operator is in a position to monitor on that channel without affecting service. With the key lever in the TALK position, the telephone set is bridged across the two-wire side of the hybrid coil and the attendant is in a position to talk either to the switchboard operator or over the carrier channel. Only channel 1 can be used for communication with the intermediate repeaters.

b. Telephone Terminal CF–1–B.

(1) The talking and monitoring circuit at Telephone Terminal CF–1–B is arranged to be used on channels terminated on either a two-wire or four-wire basis. As shown in figure 68, the transmitting side of the talking circuit for each channel is bridged across the secondary winding of hybrid coil H and the receiving side is bridged across the outputs of the channel amplifiers. The circuit elements are mounted on the talk and signal panel. (See fig. 25.)

(2) Operation of the TALK-MON key on the channel panel (figs. 21 and 23) to the TALK or MON position connects the channel over which it is desired to talk or monitor to the telephone circuit. (See fig. 68.) The circuits from these keys are bridged into a common talking circuit under the control of the two-position TEL key on the talk and signal panel. The normal position, designated LINE OR 2W SWBD, connects the talking circuit for talking over a channel toward the opposite terminal or to the switchboard when the channel is terminated on a two-wire basis. When the channel is terminated on a four-wire basis, the LINE OR 2W SWBD position connects the telephone circuit for talking over the carrier system to the opposite terminal. If it is desired to talk over the circuit connected to the channel on a four-wire basis, the 4W EXT position of the TEL key is used.

(3) The receiver circuit of the handset terminates in repeating coil R, and the transmitter of the handset terminates in induction coil T. The other sides of these coils are connected to the TEL key. Direct current for operating the transmitter of the handset is obtained from the 6.3-volt a-c heater supply. This is rectified by the copper-oxide varistor, rectifier T. Electrolytic capacitors T smooth out the rectified current which is then applied to the transmitter under control of the push-to-talk key on the handset.

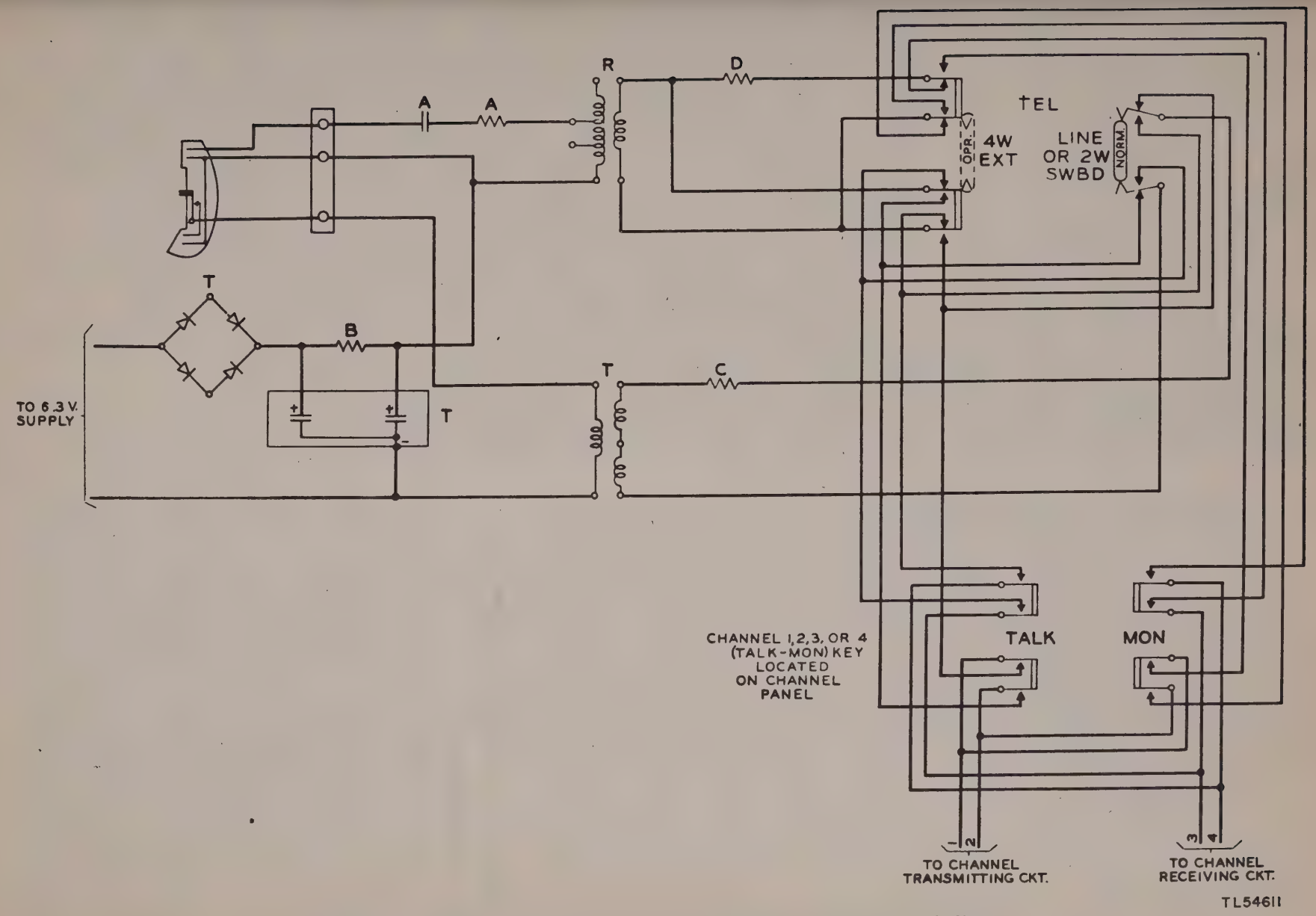

Figure 68. Telephone Terminal CF–1–B, talking and monitoring circuit, schematic diagram.

Resistor B limits the value of current to the transmitter.

c. Repeater CF–3–A. (1) A handset is mounted on the bay for communication over channel 1. A three-position key on the talk and signal panel selects the direction of call. In the normal position the handset is disconnected from the circuit. With the key in position A, the handset is in condition for communicating with terminal A or with repeaters toward terminal A. Throwing the key to position B places the handset in condition for communication with terminal B or with repeaters toward terminal B. After the repeater attendant is assured that channel 1 is not being used for service by monitoring A and B, talking battery is applied by turning the switch on the handset. Monitoring is accomplished without affecting normal service and the bridging loss when talking is negligible. No arrangement is provided at a repeater for communication over channels 2, 3, or 4.

(2) The monitoring or listening circuit is connected into the feedback circuit of the amplifier receiving from the calling terminal or repeater. (See fig. 68.) The talking circuit is bridged across the input of the amplifier transmitting toward the calling station. The TEL key connects the listening and talking circuits to the correct amplifiers. Low-pass filters are included in both listening and talking circuits to avoid interference between the repeater operator and talkers who may be on the other channels. Talking battery is supplied by the power supply circuit.

Section XV. TROUBLE LOCATION

153. Test Equipment

The transmission testing equipment required for initially adjusting the system and for making periodic adjustments after it has been placed in service is included as part of the carrier terminal and repeater equipment. At the terminals the testing equipment includes a source of 1,000-cycle testing power which may be applied to each channel, and means for measuring the testing power. At Telephone Terminal CF–1–A the testing power is measured at the output of the transmitting and receiving amplifiers and at the output of the hybrid coil at the two-wire receiving point of each channel. In Telephone Terminal CF–1–B the measuring circuit is connected at the output of the transmitting and receiving amplifiers and at the output of the channel amplifiers ahead of the hybrid coils whether the channel is terminated on a two-wire or four-wire basis. At Repeater CF–3–A the measuring circuit is arranged to measure the output of each amplifier. A source of testing power is not provided at repeaters. The measuring circuit is arranged so that these measurements can be made without affecting service except on the channel over which testing power is being transmitted. If a terminal or repeater is defective, tests may be made on the individual unit to determine the part of the circuit or piece of apparatus which is in trouble. Detailed procedures and requirements are covered in paragraphs 162 to 165.

154. Testing Arrangements at Telephone Terminal CF–1–A

a. Figure 69 is a schematic diagram of the measuring circuit at Telephone Terminal CF–1–A. A front view of the measuring panel is shown in figure 17. Testing power of 1,000-cycle frequency is supplied at the terminals by a single-tube oscillator mounted on the measuring panel. The oscillator normally is left turned off to reduce the load on the power supply panel, particularly during battery operation. It is turned on by the OSC switch. The oscillator output power is read on the measuring circuit (*c* below), and is adjusted by the CAL potentiometer to —4 dbm as read on the upper scale of the meter. The oscillator uses Tube VT–116 or VT–116–A (6SJ7 or 6SJ7GT).

b. A key is provided on each channel panel for applying the 1,000-cycle testing power at the points designated S in figures 31 and 69. These SEND keys are shown on figures 20 and 22. Throwing the key to the SEND position disconnects the hybrid coil and applies a —4-dbm testing power to the channel. This is equivalent to sending about 1 milliwatt (0 dbm) at the two-wire input to the channel, 4 db being approximately the loss through the hybrid coil. Sending on more than one channel simultaneously does not appreciably affect the testing power output on each channel. Table XXVIII gives the frequencies of the testing power as measured at the output of the transmitting and receiving amplifiers and at the output of the repeater amplifiers.

Table XXVIII.—Test frequencies

Send 1,000 cycles on channel	Line frequency (cycles)
1	1,000
2	4,900
3	7,850
4	10,800

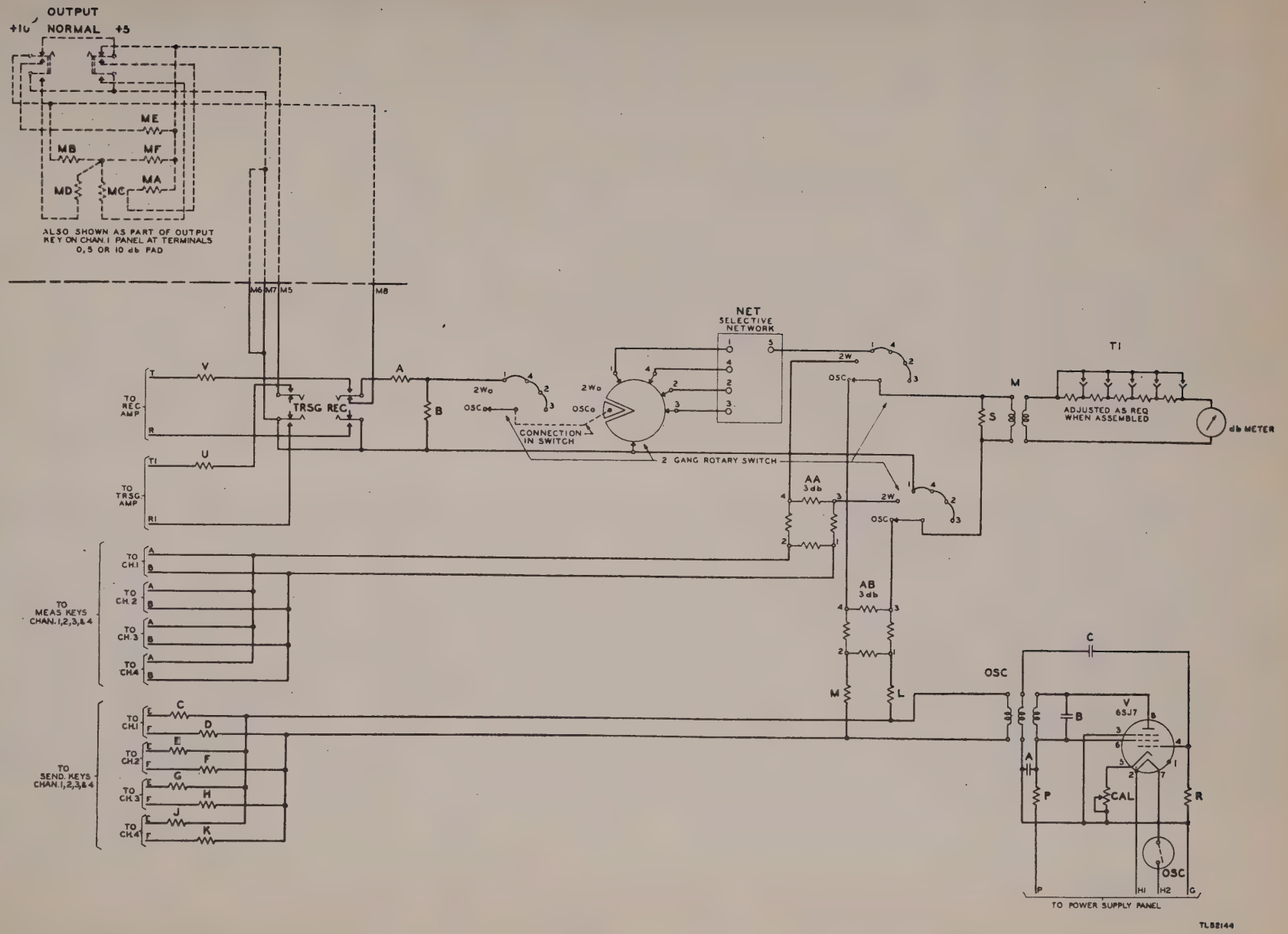

Figure 69. Telephone Terminal CF–1–A, measuring circuit, schematic diagram.

c. The measuring circuit consists of a meter and a network controlled by a switch. Six positions of the switch connect the meter to the oscillator output OSC, to the 2W position associated with the two-wire sides of the hybrid coils, and to each of four selective networks. Each of the selective networks are tuned to one of the four channel testing frequencies given in table XXVIII in *b* above. Thus a measurement of a testing frequency can be made at the output of the transmitting and receiving amplifiers for any channel while the other channels are in use. For these measurements, the meter is connected into the amplifier circuit in such a manner that it measures the power output of the amplifier when terminated in the spiral-four cable impedance with negligible loss to the through circuit. The network positions of the switch are designated 1, 4, 2, and 3, corresponding to the order in which the channels are measured during line-up procedure.

d. Under normal conditions the carrier system will be operated so that, with 1 milliwatt of testing power connected to the two-wire branch at the transmitting terminal, 1 milliwatt of power will be delivered to the line. Under some conditions it will be desirable to deliver more power to the line and the lever of the OUTPUT key will be thrown to the +5DB or +10DB position. With the key lever in the +5DB position, a testing power of +5 dbm is delivered to the line. With the key lever in the +10DB position, +10 dbm of testing power is delivered to the line. To facilitate measuring the output power from the transmitting amplifier, the OUTPUT key also controls pads in the circuit of the transmission measuring set. The purpose of these pads is to permit the meter to read 0 dbm under either of these two conditions. With the OUTPUT key in the +5DB position a 5-db pad is inserted in the measuring circuit and the meter will read 0 dbm if a power of +5 dbm is being delivered to the line. In the same way, with the lever of the OUTPUT key thrown to the +10DB position, a 10-db pad is inserted in the measuring circuit and the meter will read 0 dbm if +10 dbm is delivered to the line. The conditions under which the OUTPUT key is operated are described in paragraphs 98*c* and 100*d*. In the receiving direction the system is lined up to obtain 0 dbm at the output of the receiving amplifier regardless of the adjustment at the sending terminal. Consequently the OUTPUT key at a terminal does not change the transmission measuring circuit when measuring the output of the receiving amplifier.

155. Testing Arrangements at Telephone Terminal CF–1–B

a. With minor differences, the measuring circuit at Telephone Terminal CF–1–B is similar to that of Telephone Terminal CF–1–A. It functions in the same manner as the circuit for Telephone Terminal CF–1–A. Figure 70 is a schematic diagram of the measuring circuit at Telephone Terminal CF–1–B. The measuring panel is the same as that for Telephone Terminal CF–1–A (fig. 17) except that the designation 2W on one of the switch positions is changed to NET LOSS.

b. In Telephone Terminal CF–1–B the measuring circuit is connected to the output of the channel amplifiers. (See figs. 31 and 70.) Thus the channel net loss is measured at the same point whether the channel is terminated on a two- or four-wire basis. Since the test power as measured at the amplifier output is greater than if it were measured at the channel binding posts, a 600-ohm resistor AC has been added to the measuring circuit to lower the power read on the meter to that which would be read if the meter were connected across the CHANNELS-2W OR 4W TRANSMITTING binding posts when the channel is terminated on a two-wire basis, or across the CHANNELS-4W RECEIVING binding posts when the channel is terminated on a four-wire basis. Two 150-ohm resistors T and R have been placed in the transmission circuit ahead of the CHANNELS-4W RECEIVING binding posts so that a given net loss reading on the meter will provide approximately the same net loss at the channel binding post whether the channel is terminated on a two- or four-wire basis.

c. No change is made in the 1,000-cycle test oscillator circuit. It is connected to the individual channels at the same point in the circuit as in Telephone Terminal CF–1–A.

156. Testing Arrangements at Repeater CF–3–A

a. The transmission measuring circuit at a repeater point includes only the meter circuit. Front and rear views of the measuring and binding post panel at Repeater CF–3–A are shown in figures 28 and 72, and a schematic diagram of the circuit is shown in figure 71. The measuring circuit consists of a four-position selector switch and the meter circuit. The MEAS key permits the measuring circuit to be connected to the output of the amplifier in the AB or BA direction.

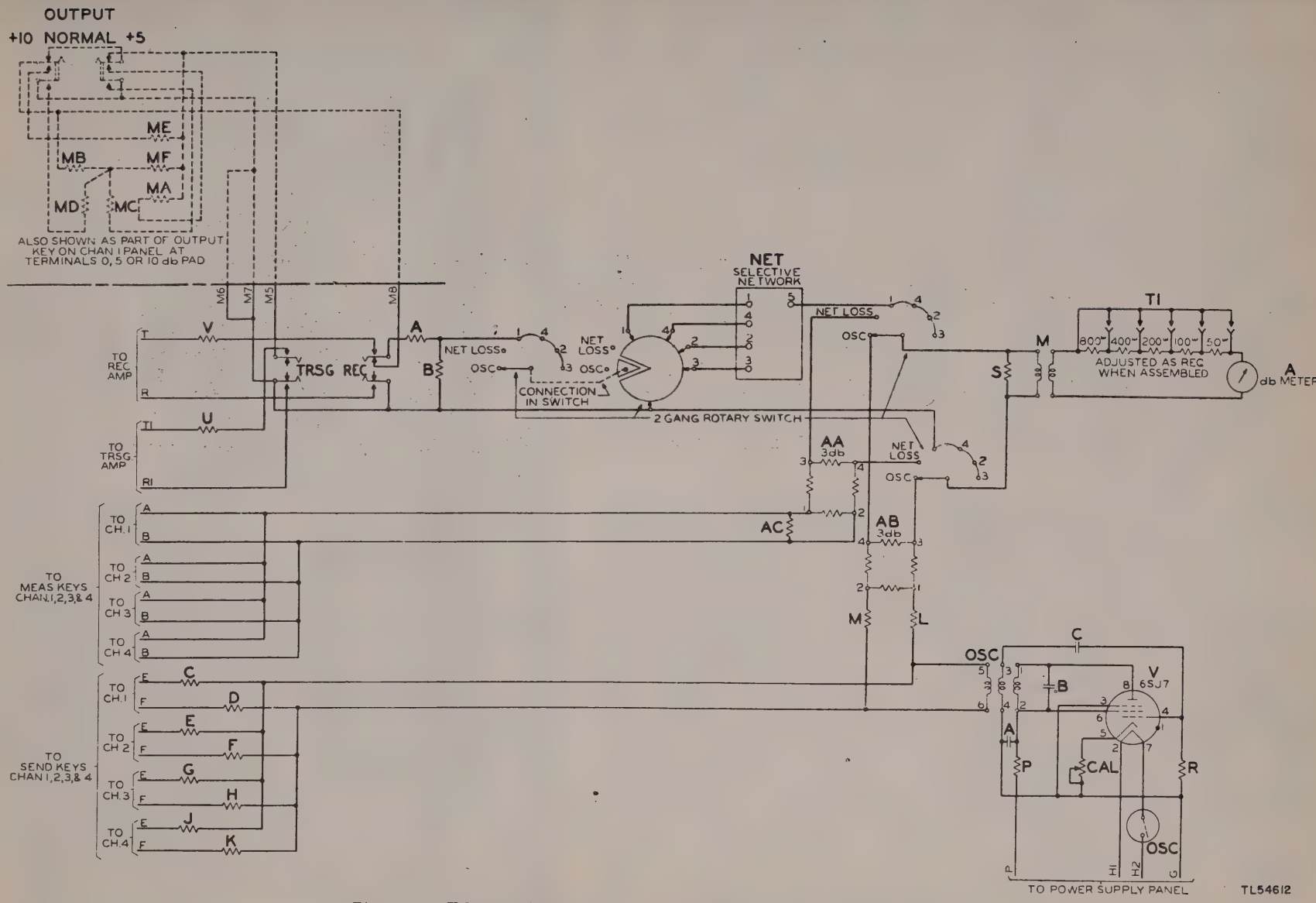

Figure 70. Telephone Terminal CF–1–B, measuring circuit, schematic diagram.

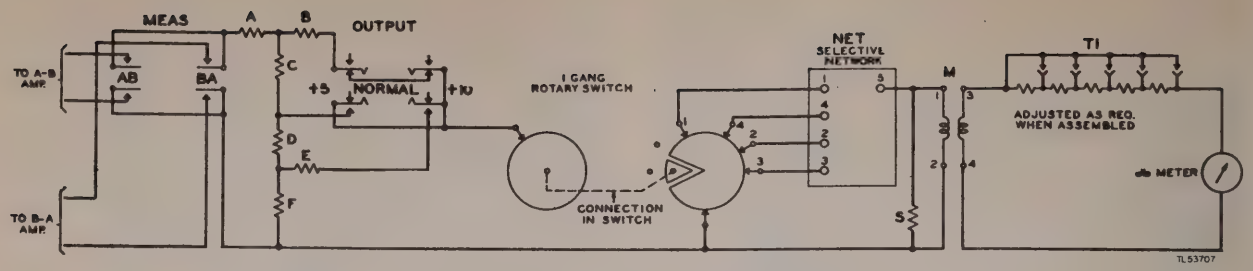

Figure 71. Repeater CF–3–A, measuring circuit, schematic diagram.

b. An OUTPUT key is provided at the repeater point which controls pads in the measuring circuit. This key has three positions, designated NORMAL, +5DB, and +10DB. With the key lever in the NORMAL position, a testing power of 0 dbm at the output of the repeater will read 0 dbm on the meter. With the key in the +5DB position, a testing power of +5 dbm at the output of the repeater will read 0 dbm on the meter. With the key lever in the +10DB position, a testing power of +10 dbm at the output of the repeater will read 0 dbm on the meter. Normally the carrier system will be lined up so that the testing power output at each repeater will be 0 dbm. If the terminal throws the lever of the OUTPUT key to send +5 dbm or +10 dbm to the line, the power received at the repeater point will be 5 db or 10 db greater than normal and the output power of the repeater delivered to the line also will be 5 db or 10 db greater. To facilitate measuring the output power at the repeater under these conditions, the OUTPUT key lever at the repeater should be thrown to NORMAL, +5DB, or +10DB when instructed to do so by the control terminal.

157. System Troubles

The general procedure for locating and clearing troubles in the system is to first localize the trouble to a particular terminal, repeater, or section of cable. After localizing the trouble, tests on the individual unit in trouble may be made. Where the trouble is located in a carrier terminal or repeater and cannot be taken care of by simple measures such as readjustment of gains, replacing vacuum tubes, cleaning or replacing carbon block protectors, or inspection of wiring, the defective terminal or repeater should be replaced and returned to a higher echelon of repair where facilities for more complete tests are provided.

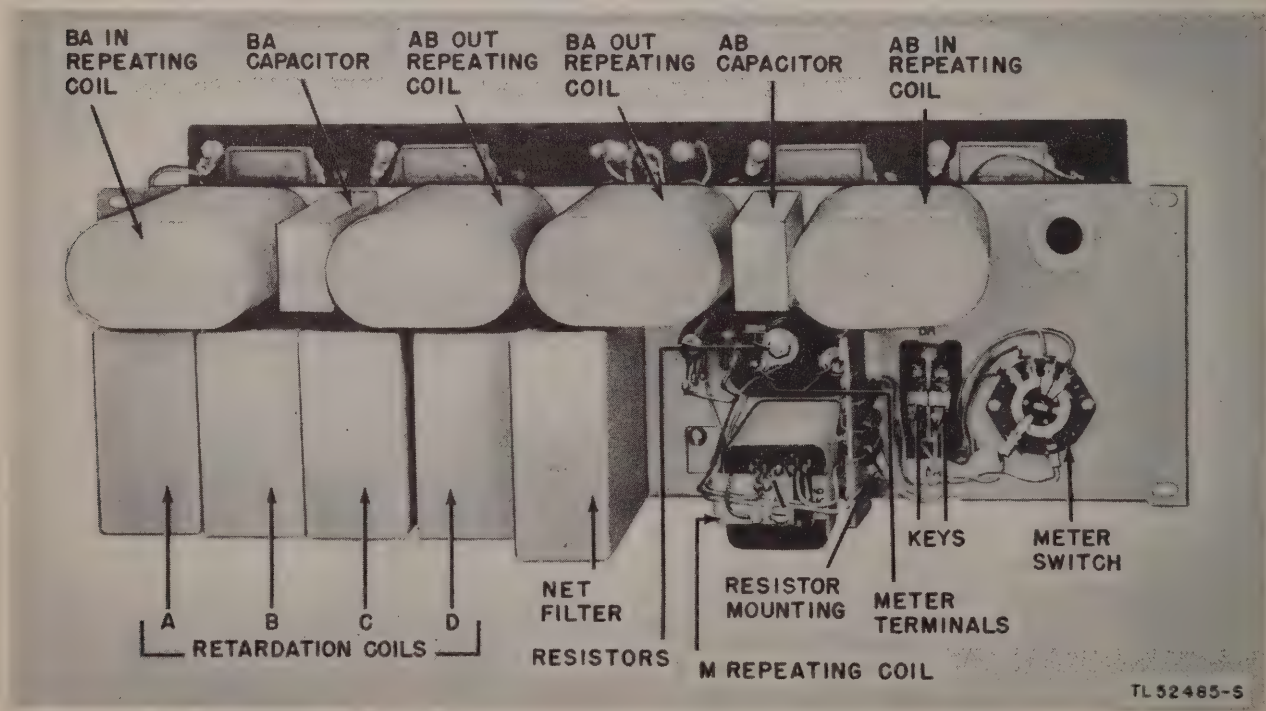

Figure 72. Repeater CF–3–A, measuring and binding post panel, rear view.

158. Localizing Troubles

Troubles in the system will generally be found as a result of inability to meet adjustments specified when lining up the system, unsatisfactory speech transmission, or failure of the voice-frequency telegraph to operate satisfactorily over the system.

a. When channel or system troubles are reported, make talking and listening tests to determine, if possible, the nature of the trouble, the number of channels in trouble, and whether one or both directions of transmission are affected. Table XXIX will provide a general indication of the location of the trouble.

b. In case of complete failure of all channels in one or both directions of transmission, each terminal should call and talk to each repeater in succession up to the point where communication is no longer possible. This will locate the particular repeater or section of cable which is in trouble.

Table XXIX.—Trouble location chart

Circuits affected	Probable location of trouble
All channels in both directions.	Cable. Power supply at terminal or repeater.
All channels in one direction	Cable. Repeater. Common transmitting and receiving branch at terminal.
One channel in one direction	Channel equipment at terminal.
Channel 2, 3, or 4 in both directions.	Carrier supply at terminal.
Signaling and alarm circuit	One wire of cable pair open.

Table XXX.—Trouble-shooting chart

Trouble indication	Probable cause	Correction
Power vibrator operates with alternating current on.	1-ampere fuse blown due to short in circuit.	Inspect wiring. Remove short and replace fuse.
	1-ampere fuse blown due to faulty fuse holder.	Replace fuse holder (par. 176). Replace fuse.
	Wrong power connections	Check connections on power supply terminal strip (par. 61).
	Relay R not operated (defective)	Replace relay.
	Relay R not operated (open circuit in relay winding).	Repair open or replace relay.
Power vibrator fails with alternating current off.	10-ampere fuse blown due to short in circuit.	Inspect wiring. Remove short and replace fuse.
	Leads to battery open	Repair open.
	Battery dead	Recharge (pars. 177 and 178) or replace.
	Vibrator needs replacement	Replace vibrator.
	Relay R does not release or contacts bad	Adjust contacts (par. 175c) or replace relay.
All channels out in both directions.	Cable trouble in both pairs	Locate trouble. Clear.
	Power failure at repeater or terminal	Battery dead. Recharge (pars. 177 and 178) or replace. Circuit trouble. Check power connections. (See par. 61.)
All channels out in one direction	Cable trouble in one pair	Locate trouble. Clear.
	TRSG branch at one terminal or REC branch at other terminal defective.	Check connections on binding post panel. (See pars. 64 to 66.) Check tubes in line amplifier panel. (See par. 76.) Replace. Protector blocks dirty. Clean or replace.
	One amplifier AB or BA at repeater defective.	Check tubes. (See par. 76.) Replace.
Channel 2, 3, or 4 out in both directions.	Carrier supply at one terminal defective	Check oscillator tubes. (See par. 76.) If defective, replace. Check for open contacts or broken wiring on MEAS key. Clean contacts or repair wiring.
One channel out in one direction	Channel equipment at one terminal defective.	Check channel amplifier tubes. (See par. 76.) Replace if defective. Check for open contacts or broken wiring on SEND key in transmitting direction. Clean contacts or repair wiring.
Circuit sounds hollow or sings	Net loss too low	Readjust GAIN dial. Check cable for trouble in line.
	OUTPUT or REC LEV key levers at either terminal in wrong position.	Readjust OUTPUT or REC LEV key lever.
	System needs lining up if all channels are affected.	Line up system. (See pars. 87 to 94.)

Table XXX.—Trouble-shooting chart—Continued

Trouble indication	Probable cause	Correction
All channels noisy	Open conductor	Test to locate opens or grounds on cable conductor. Repair open.
	High-resistance contact at a cable connector.	Locate trouble, clean.
	Grounded protector	Clean or replace protectors.
	Noisy tube in repeater or in REC or TRSG amplifier.	Replace vacuum tubes.
	Excessive static due to heavy thunderstorms.	
Poor quality	Circuit net loss too low	Readjust GAIN control.
	Circuit net loss high	Readjust GAIN control.
	Defective tube in channel amplifier	Replace vacuum tubes.
	Oscillators not in synchronism	Line up system, check synchronism (par. 169). If beats number more than five per second or if meter reading is steady, make oscillator frequency adjustment. (See par. 180.)
Talking on one channel causes noise on others.	Defective tube at repeater or in REC or TRSG amplifier.	Replace vacuum tube.
	Channel improperly lined up	Line up channel.
All channels working but signal circuit fails.	Leak to ground on signaling pair	Clean or replace protectors.
		Locate and remove ground.
	Wiring discontinuity or ground at a repeater or terminal.	Inspect wiring.
		At terminal:
		Check for dirty contacts on BATTERY-GROUND key. Clean.
		Check for dirty contacts on SIGNAL key. Clean.
		At repeater:
		Check for broken strap between SX terminals. Replace.

159. Use of Diagrams and Charts

a. Wiring details, in the form of circuit labels, are shown in figures listed below. These labels, except for the wiring diagrams of the power supply panels are mounted on the front and rear covers of the equipment. Make reference to them when clearing trouble. The wiring diagrams for the power supply panels are mounted inside the covers of the power supply panels.

b. The wiring diagrams utilize the airline system of showing connections. Each piece of apparatus is numbered and lines representing the individual wires are carried from each piece of apparatus to a common base line. These lines are marked with the color of the wire and are numbered to correspond to the apparatus number to which the other end connects. It is not necessary to follow a connection through the base line and no provision is made for doing so. By observing the color and identification number it is possible to move directly to the other end of the wire.

c. Some of these circuits contain coils which may be permanently injured when the cores are magnetized by direct or excessive alternating current flowing through their windings. *Do not use ordinary d-c buzzers and similar equipment for making continuity tests.* A voltohmmeter is satisfactory if it is used on the highest resistance scale (highest multiplier).

160. Measurement of Power Supply and Vacuum Tube Voltages

a. Before making tests to locate trouble, test all vacuum tubes according to the directions given in paragraph 76. Operate the terminal or repeater for a period of 5 minutes after the power is applied to permit the tubes to stabilize before making measurements.

b. With vacuum tubes in each socket and the power supply connections made (par. 61), the power supply voltages should meet the limits covered in table XXXI. Use Voltohmmeter I–166 for these measurements. For the d-c measurement the plus terminal is given first. These limits apply to the power supply panel at a repeater and to each of the power supply panels at a terminal.

Caution: Hazardous voltages appear between certain apparatus terminals and the framework or

ground when the power is turned on. Be careful to avoid touching exposed terminals with the bare hands.

All testing will be done with well insulated test leads.

c. The vacuum tube operating voltages as measured at the tube socket terminals should meet the limits specified in tables XXXII to XXXV for a terminal and table XXXII for a repeater.

161. Transmission Measuring Equipment

a. For trouble tests on terminals and repeaters the following testing equipment may be used:

(1) Audio Oscillator TS–379/U, or equivalent.

(2) Decibel Meter TS–399/U, TS–400/U, or equivalent.

(3) Attenuator TS–402/U, or equivalent.

(4) Voltohmmeter I–166.

(5) Tube Tester I–177.

Note.—Test Set I–120 consists of an oscillator, a transmission measuring set, and a gain adjunct. The gain adjunct consists of a 20- and a 30-db pad. Audio Oscillator TS–379/U, Decibel Meter TS–399/U or TS–400/U, and Tube Tester I–177 can be operated only where a 110- to 125-volt, 50- to 60-cycle a-c power supply is available.

b. Other testing equipment may be used providing it meets the following general requirements:

(1) An oscillator with a frequency range of 200 to 12,000 cycles, a frequency accuracy of ±20 percent at 200 cycles and ±1 percent at 12,000 cycles, an output of −4 to +6 dbm, and an impedance of 600 ohms.

(2) A transmission measuring set with a frequency range of 200 to 12,000 cycles, sensitivity of −45 to +10 dbm, accuracy of ±0.5 db, and an impedance of 600 ohms.

(3) An attenuator with a frequency range of 200 to 12,000 cycles, an attenuation range of 0 to 50 db in 1-db steps, accuracy of ±0.2 db, and an impedance of 600 ohms.

(4) A voltohmmeter with a-c and d-c voltage ranges of 0 to 15, 0 to 30, 0 to 150, and 0 to 300 volts, and a-c voltage accuracy of ±5 percent (1,000 ohms per volt), a d-c voltage accuracy of ±2 percent (1,000 ohms per volt), a resistance range of 0 to 1,000,0000 ohms, and a resistance accuracy of 5 percent.

162. Transmission Measurements

a. For transmission measurements, test power is applied and the characteristics of the circuits measured at certain points. The test points are chosen for their accessibility. By this process the portion of the circuit in trouble is segregated. Certain individual parts such as equalizers and amplifiers may also be measured individually to determine that they meet their characteristics. Tables XXXV to XLIII, and tables XLVI and XLVII give limits for certain tests based upon a meter reading obtained in a previous test. For example, as A−3.0 to A+2.0 where A is the meter reading previously obtained. Consequently, where the limit given is A−3.0 to A+2.0 and the meter reading for A is −1 dbm, the limits to be met are the algebraic addition of these two, in this case −1−3=−4 and −1+2=+1. Therefore the limits are −4 dbm to +1 dbm.

b. The transmission measurements on Telephone Terminal CF–1–A are covered in tables XXXV, XXXVII, XXXIX, and XLI, and transmission measurements on Telephone Terminal CF–1–B are covered in tables XXXVI, XXXVIII, XL, and XLII. Transmission measurements on Repeater CF–3–A are covered in table XLIII.

c. Certain parts of the equipment that can be tested individually, such as filters, equalizers, amplifiers, and oscillators, to determine that their transmission characteristics are satisfactory are covered in tables XLIV to XLVII.

163. Test Procedure for Telephone Terminal CF–1–A When no Testing Equipment is Available

If transmission measuring equipment listed in paragraph 161 is not available, a quick check of Telephone Terminal CF–1–A may be made as covered in table XLVIII by connecting the transmitting branch of the terminal back to its receiving branch and using the measuring equipment associated with the terminal. This is done as follows:

a. Set the four dials of the terminal equalizer panel and the four channel GAIN dials as shown in table XLVIII.

b. Connect the TRSG binding posts to the REC binding posts using strap wire.

c. Calibrate the oscillator by turning the switch of the measuring set to OSC and adjusting the CAL potentiometer until the meter reads −4 dbm on the upper scale of the meter.

d. Proceed to test the terminal as covered in table XLVIII. If only one of the tests A, D, E, and F is outside limits, the trouble is probably in the channel transmitting branch. If two or more of the tests are out of limits, the trouble is probably in the common transmitting branch including the OUTPUT key and its associated pads,

the TRSG amplifier, and the line repeating coil. Likewise, if only one of the tests G, H, I, and J are out of limits the trouble is probably in the channel receiving branch. If two or more of these tests are out of limits, the trouble is probably in the common receiving branch including the line coil, REC amplifier, and the REC LEV key and its associated pad. Tests A, B, and C check the operation of the OUTPUT key and its associated pads in both the transmitting branch and in the measuring circuit.

164. Test Procedure for Telephone Terminal CF–1–B When no Testing Equipment is Available

When no testing equipment is available for testing Telephone Terminal CF–1–B set up the equipment as for Telephone Terminal CF–1–A (par. 163) and check the terminal, using table XLVIII. *Note that the measuring panel switch position designated 2W on Telephone Terminal CF–1–A is designated NET LOSS on Telephone Terminal CF–1–B.* When making these tests the channel 2 WIRE–4 WIRE key may be in either position.

a. Since the measuring circuit in Telephone Terminal CF–1–B is connected at a different point than in Telephone Terminal CF–1–A, Telephone EE–8–(*) should be used to check the channel terminations as follows:

(1) Connect Telephone EE–8–(*) to the CHANNELS-4W RECEIVING binding posts of the channel under test. Operate the associated channel 2 WIRE–4 WIRE key on the talk and signal panel to 4 WIRE. With the 1,000-cycle tone on the transmitting side of the channel and with the TRSG and REC binding posts connected together, listen for the tone in the receiver of Telephone EE–8–(*). If no tone is heard, trouble is indicated between the channel amplifier and the CHANNELS-4W RECEIVING binding posts.

(2) Connect Telephone EE–8–(*) to the CHANNELS-2W or 4W TRANSMITTING binding posts. Operate the channel 2 WIRE–4 WIRE key to 2 WIRE and listen for the tone. If no tone is heard, trouble is indicated between the channel amplifier and the CHANNELS-2W OR 4W TRANSMITTING binding posts.

b. The telephone circuit may be tested as follows:

(1) The TRSG and REC binding posts must be connected together, the charge 2 WIRE–4 WIRE key must be in the normal (2 WIRE) position, and the equalizer dials should be set as given in table XLVIII.

(2) Operate the channel SEND key. Operate the channel TALK-MON key to MON. Operate the TEL key to LINE OR 2W SWBD. The 1,000-cycle tone should be heard in the receiver of the handset.

(3) Repeat this test with the TALK-MON key in the TALK position. Restore the SEND key to normal. Operate the channel TALK-MON key to TALK. Operate the TEL key to LINE OR 2W SWBD. Operate the selector switch on the measuring panel to the channel number of the channel under test, and operate the key or the measuring panel to TRSG. With the key on the handset operated, whistle into the transmitter. Note that a reading is obtained on the meter on the measuring panel.

(4) Restore the key on the measuring panel to normal. Remove the strap between the TRSG and REC binding posts. Connect Telephone EE–8–(*) to the CHANNELS—2W OR 4W TRANSMITTING binding posts.

(5) Operate the channel TALK-MON key to TALK and the TEL key to 4W EXT. Talk from the handset and listen to voice on Telephone EE–8–(*), then talk from Telephone EE–8–(*) and listen to voice on the handset.

(6) Operate the channel TALK-MON key to MON and the TEL key to 4W EXT. Talk on Telephone EE–8–(*) and listen to voice on the handset.

(7) If any of the above tests are not met trouble is indicated in the TALK-MON or TEL keys, the wiring of the telephone circuit, or wiring to the channel panels.

(8) Disconnect Telephone EE–8–(*) and restore the TALK-MON and TEL keys to normal.

165. Test Procedure for Repeater CF–3–A When no Testing Equipment is Available

A quick check of a repeater can be made at a point where a terminal is available and when transmission measuring equipment is not available. After making tests on the terminal as covered in tests A through J in table XLVII proceed as follows:

a. Set the dials on the repeater for both the AB and BA equalizers as shown in table XLIX.

b. Set the dials of the terminal as covered in paragraph 163*a*.

c. Connect the TRSG binding posts of a terminal to the AB IN binding posts of the repeater.

d. Connect the AB OUT binding posts of the repeater to its BA IN binding posts.

e. Connect the BA OUT binding posts of the repeater to the REC binding posts of the terminal.

f. Proceed to test as in table XLIX. If trouble is indicated in the measuring circuit at a repeater, an over-all test of both the AB and BA amplifiers can be made, using the terminal measuring set, by operating the meter key at the terminal to REC. Otherwise follow test E, F, G, and H in table XLIX.

166. Checking Power Supply Circuit

Where trouble is located in a terminal or repeater, check the power supply to see whether the unit is operating on the a-c supply or 12-volt battery. The relay R will be operated if the main a-c supply has not been interrupted. Operation on the 12-volt battery is indicated by the audible hum of the vibrator. A check should be made to be sure that the 12-volt battery is in a properly charged condition. (See TM 11–430.) If trouble is indicated when operating from the 12-volt battery and the battery is in a properly charged condition, replace the vibrator.

167. Poor Transmission

Where complete failure has not occurred, troubles will usually be evidenced by poor transmission, excessive noise, or poor quality. In these cases make a line-up test of the system (pars. 87 to 94) to be sure that the trouble is not caused by improper adjustments. Situations which may cause these types of troubles are discussed in *a* and *b* below.

a. Poor transmission indicates that the circuit net losses are outside of their limits by substantial amounts. Where the circuit sounds hollow or sings, the channel net loss is too low. This is usually caused by unsatisfactory system line-up which can be corrected by readjustment. A net loss that is too high may be caused by cable trouble, improper adjustment, or trouble in a terminal or repeater resulting in inadequate gain.

b. Excessive noise on all channels may be caused by the following conditions: An open conductor, leakage to ground or braid of one wire in the cable or carrier equipment, high-resistance contact at a connector, a grounded protector, a noisy vacuum tube, a heavy thunderstorm in vicinity, or trouble in nearby power systems. It may be possible to determine where noise is entering the circuit by monitoring on channel 1 at each repeater. Cleaning protectors or replacing vacuum tubes may clear the trouble. Make tests to locate opens or grounds on the cable conductors in the sections affected. *To avoid electric shock, be careful when removing or replacing carbon blocks during lightning storms.* If excessive noise on one or more of the telephone channels is appreciably reduced when the d-c telegraph is disconnected from the SX binding posts, the noise sometimes may be reduced by inserting inductance in the simplex circuit using Coil C–161 connected as follows: Connect one LINE binding post to one SWBD binding post and to the d-c telegraph circuit. Connect the second LINE binding post to the second SWBD binding post and to the SX binding post of the terminal or repeater. Do not connect to the center tap TELEG binding post. Note whether the noise is reduced when the d-c telegraph is operating or not operating. If it is not reduced, interchange the connections to the two SWBD binding posts. Again note whether the noise is reduced. If it is reduced leave the coil in that circuit. If it is not reduced remove the coil. If the trouble causing the noise cannot be located it may be necessary to make readjustments in the system line-up. (See par. 87.)

168. Interchannel Interference

Talking on one channel may cause noise on other channels if the outputs are allowed to become too high or if a faulty vacuum tube is in one of the line amplifiers. The presence of such interchannel interference may be checked by talking at a normal volume on channels 2 and 4 and listening on channel 1. Vacuum tubes should be changed at the transmitting terminal and each repeater in succession to determine if a faulty vacuum tube is being used.

169. Poor Quality

Poor quality or loss of naturalness in speech over a channel may be caused by too low circuit net loss, a defective vacuum tube in the channel amplifier at the receiving terminal, or a lack of synchronism between the carrier oscillators at the two terminals. If changing vacuum tubes in the channel amplifier and lining up the system again does not clear the trouble, check the synchronism as follows:

a. Send 1,000-cycle test power from terminal A on channel 1 and on the channel under test by operating the keys on the channel 1 panel and the channel panel of the channel under test to the SEND position.

b. At the receiving terminal, measure both test tones simultaneously by operating the keys on the channel 1 panel and the channel panel of the channel under test to the MEAS position. An excessive difference in frequency between the carrier oscillators at the two terminals will be evi-

denced by a fast beat on the meter or, if too far apart, by a steady meter reading. A small difference in frequency is indicated by a slow beat.

c. If the number of beats is greater than five per second or if the meter reading is steady, the frequency of the oscillator at terminal B should be readjusted until the number of beats is less than one per second. See paragraph 180 for directions on making the oscillator frequency adjustment.

Table XXXI.—Power supply voltage limits, power supply panels, telephone terminal CF–1–(*) and repeater CF–3–A

Measurement of—	Terminal block	Measure between terminals	Voltmeter scale	Voltage limits (volts)
A-c supply	AC	1 and 3	0–150 or 0–500 ac	110–125 or 220–250
D-c supply	DC	2 and 1	0–15 dc	10. 5–12. 0
Heater voltage*	OUTPUT	1 and 2	0–15 dc	5. 5–7. 0
Heater voltage*	OUTPUT	3 and 4	0–15 ac	5. 5–7. 0
Plate and screen voltage*	OUTPUT	5 and 6	0–500 dc	120–175
Signal bell voltage*	OUTPUT	7 and 8	0–150 ac	52–66

*Repeat with a-c plug disconnected.

Table XXXII.—Vacuum tube operating voltages, line amplifier panel, telephone terminal CF–1–(*) and repeater CF–3–A

Measurement of—	Tube socket designation	Measure between terminals	Voltmeter scale	Voltage limits (volts)
Heater voltage	V1	2 and 7	0–15 ac	5. 5 to 7. 0
Plate voltage	V1	8 and 5	0–150 dc	85 to 135
Screen voltage	V1	6 and 5	0–150 dc	85 to 135
Cathode bias	V1	2 and 5	0–15 dc	2. 0 to 5. 0
Heater voltage	V2	2 and 7	0–15 ac	5. 5 to 7. 0
Plate voltage	V2	3 and 8	0–500 dc	110 to 175
Screen voltage	V2	4 and 8	0–500 dc	110 to 175
Cathode bias	V2	2 and 8	0–15 dc	4. 0 to 12. 0

Note.—The line amplifier panel includes two amplifiers, each of which has a V1 (6SJ7) tube and a V2 (6V6GT) tube.

Table XXXIII.—Vacuum tube operating voltages, channel panels and measuring panel, Telephone Terminal CF–1–A

Measurement of—	Panel	Equipment designation	Measure between terminals	Voltmeter scale	Voltage limits (volts)
Heater voltage	CH 1, 2, 3, 4	Tube socket 1	2 and 7	0–15 ac	5.5 to 7.0
Plate voltage	CH 1, 2, 3, 4	Tube socket 1	8 and 5	0–500 dc	100 to 165
Screen voltage	CH 1, 2, 3, 4	Tube socket 1	6 and 5	0–150 dc	60 to 110
Cathode bias	CH 1, 2, 3, 4	Tube socket 1	Resistor AE	0–15 dc	1.0 to 4.0
Heater voltage	CH 2, 3, 4	Tube socket OSC	2 and 7	0–15 ac	5.5 to 7.0
Plate voltage	CH 2, 3, 4	Tube socket OSC	8 and 5	0–500 dc	100 to 170
Screen voltage	CH 2, 3, 4	Tube socket OSC	6 and 5	0–500 dc	100 to 170
Limited bias	CH 1	Varistor V	3 and 1	0–15 dc	0.8 to 1.8
Heater voltage	MEAS	Tube socket V	2 and 7	0–15 ac	5.5 to 7.0
Plate voltage	MEAS	Tube socket V	8 and 5	0–150 dc	80 to 145
Screen voltage	MEAS	Tube socket V	6 and 5	0–150 dc	80 to 145
Cathode bias	MEAS	Tube socket V	7 and 5	0–15 dc	3.0 to 6.5

Note.—CAL potentiometer set for minimum output of 1,000-cycle oscillator.

Table XXXIV.—Vacuum tube operating voltages, channel panels and measuring panel, telephone terminal CF–1–B

Measurement of—	Panel	Equipment designation	Measure between terminals	Voltmeter scale	Voltage limits (volts)
Heater voltage	CH 1, 2, 3, 4	Tube socket AMP	2 and 7	0–15 ac	5. 5 to 7. 0
Plate voltage	CH 1, 2, 3, 4	Tube socket AMP	8 and 5	0–500 dc	100 to 173
Screen voltage	CH 1, 2, 3, 4	Tube socket AMP	6 and 5	0–150 dc	60 to 140
Cathode bias	CH 1, 2, 3, 4	Tube socket AMP	Resistor AE	0–15 dc	2. 0 to 5. 0
Heater voltage	CH 2, 3, 4	Tube socket OSC	2 and 7	0–15 ac	5. 5 to 7. 0
Plate voltage	CH 2, 3. 4	Tube socket OSC	8 and 5	0–500 dc	100 to 170
Screen voltage	CH 2, 3, 4	Tube socket OSC	6 and 5	0–500 dc	100 to 170
Limiter bias	CH 1	Varistor V	3 and 1	0–15 dc	0. 8 to 1. 8
Heater voltage	MEAS	Tube socket V	2 and 7	0–15 ac	5. 5 to 7. 0
Plate voltage	MEAS	Tube socket V	8 and 5	0–150 dc	80 to 145
Screen voltage	MEAS	Tube socket V	6 and 5	0–150 dc	80 to 145
Cathode bias	MEAS	Tube socket V	7 and 5	0–15 dc	3. 0 to 6. 5

Note.—CAL potentiometer set for minimum output of 1,000-cycle oscillator.

Table XXXV.—Transmission measurement tests, Channel 1 transmitting, Telephone Terminal CF–1–A

Test	Input: Frequency (cycles)	Input: Power (dbm)	Connect oscillator to binding posts	Connect measuring set to—	Output power (dbm)	If limits are not met	If limits are met
A	1,000	0	CH1 (note 7).	TRSG binding posts	−2.0 to +2.0 (note 1).	Proceed with test E	Proceed with test B.
B1	1,000	+5	CH1 (note 7).	TRSG binding posts	A+2.5 to A+5.5	Trouble in voltage limiter or TRSG AMP.	Proceed with test C.
B2	1,000	+5	CH1 (notes 2 and 7).	TRSG binding posts	A+4.0 to A+8.0		
C1	300	0	CH1 (note 7).	TRSG binding posts	A−3.0 to A+0	Trouble in TRSG filter, TRSG AMP, coils in limiter circuit, or hybrid coil.	Proceed with test D.
C2	2,700	0	CH1 (note 7).	TRSG binding posts	A−4.0 to A+0		
D	1,000	0	CH1 (note 7).	TRSG binding posts	−1.0 to +4.0 (note 3).	Trouble in measuring circuit	No trouble indicated. Proceed with test E.
E	1,000	0	(Note 5)	TRSG binding posts	−1.0 to +4.0 (note 3).	Trouble in OUTPUT key or in associated pad.	Proceed with test F.
F	1,000	0	(Note 6)	TRSG binding posts	−1.0 to +4.0 (note 3).	Trouble in OUTPUT key or in associated pad.	No trouble indicated.
G	1,000	0	CH1	Terms 1 and 2 of TRSG filter on CH 1 panel (note 4).	−35 to −31	Proceed with test H	Trouble in coil T, TRSG AMP, or 16-db pad.
H	1,000	0	CH1	Terms 2 and 5 of A coil on CH 1 panel (note 4).	−16 to −12	Proceed with test I	Trouble in TRSG filter or 20-db pad.
I	1,000	0	CH1	Terms 4 and 7 of B coil on CH 1 panel (note 4).	−13.5 to −11.5	Proceed with test J	Trouble in voltage limiter.
J	1,000	0	CH1	Terms 1 and 2 of H coil on CH 1 panel (note 4).	−4.0 to −3.0	Trouble in H coil, MEAS or TALK keys, A, B, or C capacitor, or A resistor.	Trouble in 9.0-db pad or SEND key.

NOTES

1. Record actual reading which is referred to as A in tests B and C.
2. For this measurement short-circuit V and C resistors on channel 1 panel.
3. This reading is made on lower scale of meter on measuring panel. On measuring panel set key to TRSG position and selector switch to position 1. Set OUTPUT key to NORMAL position.
4. Remove external wiring from terminals before connecting measuring set.
5. Same as note 3 except OUTPUT key operated to +5–db position.
6. Same as note 3 except OUTPUT key operated to +10–db position.
7. For tests A, B, C, and D, OUTPUT key should be in NORMAL position.

Table XXXVI.—Transmission measurement tests, channel 1 transmitting, Telephone Terminal CF–1–B

Test	Input: Frequency (cycles)	Input: Power (dbm)	Connect oscillator to binding posts	Connect measuring set to—	CHAN 1 2-WIRE–4-WIRE key	Output power (dbm)	If limits are not met	If limits are met
A (notes 1, 2).	1,000	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	−2.0 to +2.0	Proceed with test G	Proceed with test B.
B1	1,000	+5	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	A+2.0 to A+5.5	Trouble in voltage limiter or transmitting amplifier.	Proceed with test C.
B2 (note 3).	1,000	+5	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	A+3.5 to A+8.0		
C	1,000	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	4-WIRE	A−0.5 to A+0.5	Trouble in channel 2-WIRE-4-WIRE key circuit.	Proceed with test D.
D1	300	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	A−3.0 to A	Trouble on TRSG filter transmitting amplifier, limiter circuit, or hybrid coil H.	Proceed with test E.
D2	2,700	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	A−4.0 to A		
E	1,000	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	−1.0 to +4.0 (note 4).	Trouble in measuring circuit.	Proceed with test F.
F1	1,000	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	2-WIRE	A−0.5 to A−2.5 (note 5).	Trouble in telephone circuit or TALK-MON or TEL keys.	No trouble indicated.
F2	1,000	0	CH1 2W or 4W TRANSMITTING.	TRSG binding posts	4-WIRE	A−4.0 to A−1.0 (note 5).		
F3	1,000	0	CH1 2W or 4W TRANSMITTING	TRSG binding posts	4-WIRE	A−2.0 to A (note 7).		
G (note 8).	1,000	0	CH1 2W or 4W TRANSMITTING.	Terms 1 and 2 of hybrid coil H on CH 1 panel.	2-WIRE	−4.0 to −3.0	Trouble in hybrid coil H or wiring.	Proceed with test H.

Table XXXVI.—Transmission measurement tests, channel 1 transmitting, Telephone Terminal CF–1–B—Continued

Test	Input		Connect oscillator to binding posts	Connect measuring set to—	CHAN 1 2-WIRE-4-WIRE key	Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)						
H (note 8).	1,000	0	CH1 2W or 4W TRANSMITTING.	Terms 5 and 6 of coil A on CH 1 panel.	2-WIRE	−15.5 to −11.5	Trouble in SEND key, 9-db pad, limiter circuit, or coil A.	Proceed with test I.
I (note 8).	1,000	0	CH1 2W or 4W TRANSMITTING.	Terms 1 and 2 of TRSG filter on CH 1 panel.	2-WIRE	−35.0 to −31.0	Trouble in 20-db pad, TRSG filter, or panel wiring.	Trouble in OUTPUT key, transmitting amplifier, coil T, faulty carbon block protectors, or wiring.

NOTES

1. For all tests the OUTPUT, SEND, and TALK-MON keys should be normal unless otherwise indicated.
2. Record actual reading which is referred to as A in tests B, C, D, and F.
3. For this measurement short-circuit resistors V and C on channel 1 panel.
4. This reading is made on lower scale of meter on measuring panel. Set measuring panel key to TRSG and selector switch to position 1. Repeat with OUTPUT key in +5 and +10 positions. Meter reading should remain within 0.5 db of the reading with OUTPUT key normal. If limits are not met, trouble is indicated in OUTPUT key or pad circuits. Restore OUTPUT key to NORMAL position.
5. Operate channel 1 TALK-MON key to TALK and TEL key to LINE or 2W SWBD. Operate key on handset. After noting measuring set reading, disconnect oscillator. With transmitter key operated, whistle into transmitter and note that a reading is obtained on measuring set connected to TRSG binding posts.
6. Operate channel 1 TALK-MON key to TALK and TEL key to 4W EXT. Note that a tone is heard in receiver.
7. Operate channel 1 TALK-MON key to MON and TEL key to 4W EXT. Note that tone heard in receiver is less than that in test F2.
8. Remove wiring from terminals to which measuring set is connected before connecting measuring set.

Table XXXVII.—Transmission measurement tests, channels 2, 3, and 4 transmitting, Telephone Terminal CF–1–A

Test	Input		Connect oscillator to binding posts	Connect measuring set to—	Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)					
A	1,000	0	CH2, 3, or 4	TRSG binding posts	−2.0 to +2.0 (note 1).	Proceed with test E	Proceed with test B.
B1	1,000	+5	CH2, 3, or 4	TRSG binding posts	A+3.0 to A+5.5	Trouble in channel modulator or TRSG AMP.	Proceed with test C.
B2	1,000	+5	CH2, 3, or 4	TRSG binding posts	A+4.5 to A+9.5 (note 2).		
C1	300	0	CH2, 3, or 4	TRSG binding posts	A−7.0 to A+0	Trouble in TRSG 1 or TRSG 2 filters, TRSG AMP, or channel oscillator frequency.	Proceed with test D.
C2	2,700	0	CH2, 3, or 4	TRSG binding posts	A−7.0 to A+0		
D	1,000	0	CH2, 3, or 4	TRSG binding posts	−3.0 to +3.0 (note 3).	Trouble in measuring circuit	No trouble indicated.
E	1,000	0	CH2, 3, or 4	Terms 1 and 2 of TRSG 2 filter on CH 2, 3, or 4 panel (note 4).	−36.5 to −31.0	Proceed with test F	Trouble in coil T, TRSG AMP, or 16-db pad.
F	1,000	0	CH2, 3, or 4	Terms 1 and 3 of TRSG 1 filter on CH 2, 3, or 4 panel (note 4).	−13.0 to −11.0	Proceed with test G	Trouble in TR varistor circuit, TRSG 2 filter, or 11.5-db pad.
G	1,000	0	CH2, 3, 4	Terms 1 and 2 H coil on CH 2, 3, or 4 panel (note 4).	−4.0 to −3.0	Trouble in H coil, MEAS or TALK keys A, B, or C capacitor, or A resistor.	Trouble in TRSG 1 filter, SEND key, or 8.5-db pad.

NOTES

1. Record actual reading which is referred to as A in tests B and C. Set OUTPUT key to NORMAL for all tests.
2. For this measurement short-circuit terminals of S and C resistors and channel panels.
3. This reading is made on lower scale of meter on measuring panel. On measuring panel set key to TRSG position and set selector switch as follows:
   For channel 2—position 2.
   For channel 4—position 4.
   For channel 3—position 3.
4. Remove external wiring from terminals before connecting measuring set.

Table XXXVIII.—Transmission measurement tests, channels 2, 3, and 4 transmitting, Telephone Terminal CF–1–B

Test	Input		Connect oscillator to binding posts	Connect measuring set to—	Channel 2-WIRE–4-WIRE key	Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)						
A (notes 1, 2).	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	−2.0 to +2.0	Proceed with test G.	Proceed with test B.
B1	1,000	+5	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	A+3.0 to A+5.5	Trouble in channel modulator or transmitting amplifier.	Proceed with test C.
B2 (note 3).	1,000	+5	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	A+4.5 to A+9.5		
C	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	4-WIRE	A−0.5 to A+0.5	Trouble in channel 2 WIRE-4 WIRE key circuit.	Proceed with test D.
D1	300	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	A−7.0 to A	Trouble in TRSG 1 or 2 filters, transmitting amplifier, or a high or low channel oscillator frequency.	Proceed with test E.
D2	2,700	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	A−7.0 to A		
E	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	−3.0 to +3.0 (note 4).	Trouble in measuring circuit.	Proceed with test F.
F1	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	2-WIRE	A−0.5 to A−2.5 (note 5).	Trouble in telephone circuit or TALK-MON or TEL keys.	No trouble indicated.
F2	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	4 WIRE	A−1.0 to A−4.0 (note 6).		
F3	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	TRSG binding posts.	4-WIRE	A to A−2.0 (note 7).		
G (note 8).	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	Terms 1 and 2 of hybrid coil H on channel panel.	2-WIRE	−3.0 to −4.0	Trouble in hybrid coil H or wiring.	Proceed with test H.
H (note 8).	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	Terms 1 and 3 of TRSG 1 filter on channel panel.	2-WIRE	−13.0 to −11.0	Trouble in channel SEND key 8.5-db pad, TRSG 1 filter, or panel wiring.	Proceed with test I.
I (note 8).	1,000	0	CH2, 3, or 4 2W or 4W TRANSMITTING.	Terms 1 and 2 of TRSG 2 filter on channel panel.	2-WIRE	−31.0 to −36.5	Trouble in TRSG 2 filter, modulator, pad circuits, or wiring.	Trouble in OUTPUT key, transmitting amplifier, repeating coil T, faulty carbon block protectors, or wiring.

NOTES

1. For all tests OUTPUT, SEND, and TALK-MON keys should be normal unless otherwise specified.

2. Record actual value of output power in test A. This is referred to as A in tests B, C, D, and F.

3. For this test short resistors S and C on channel panels.

4. This reading is made on lower scale of meter on measuring panel. Set measuring panel key to TRSG and switch to position 2, 3, or 4 for channel 2, 3, or 4 respectively.

5 Operate channel 2, 3, or 4 TALK-MON key to TALK and TEL key to LINE OR 2W SWBD. Operate key on handset. After noting measuring set reading, disconnect oscillator. With transmitter key operated, whistle into transmitter and note that a reading is obtained on measuring set connected to TRSG binding posts.

6. Operate channel 2, 3, or 4 TALK-MON key to TALK and TEL key to 4W EXT. Note that tone is heard in receiver.

7. Operate channel 2, 3, or 4 TALK-MON key to MON and TEL key to 4W EXT. Note that tone heard in receiver is less than in test F2.

8. Remove wiring from terminals to which measuring set is connected before connecting measuring set.

Table XXXIX.—Transmission measurement tests, channel 1 receiving, Telephone Terminal CF–1–A

Test	Input		Connect oscillator to binding posts	Connect measuring set to—	Equalizer dial settings					Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)			MILES	1	4	2	GAIN			
A1	1,000	0	REC	CH1 binding posts	20	8	0	4	21	−8.0 to −4.0 (note 1).	Proceed with test H	Proceed with test B.
A2	1,000	0	REC	CH1 binding posts	0	8	0	4	21	A+1.0 to A+3.0 (note 1).		
B	1,000	0	REC	CH1 binding posts	20	18	0	4	21	A+9.0 to A+11	Trouble in line or channel amplifiers or equalizers.	Proceed with test C.
C1	300	0	REC	CH1 binding posts	20	8	0	4	21	A−5.0 to A−1.0	Trouble in REC filter, amplifiers, or equalizer.	Proceed with test D.
C2	2,700	0	REC	CH1 binding posts	20	8	0	4	21	A−3.0 to A+1.0		
D	1,000	0	REC	CH1 binding posts	20	8	0	4	21	−1.0 to +2.0	Trouble in measuring circuit.	Proceed with test E
E	1,000	0	REC	CH1 binding posts	20	8	0	4	21	−8.0 to −4.0 (note 3).	Trouble in measuring circuit.	Proceed with test F.
F	1,000	0	REC	TEL binding posts (note 4).	20	8	0	4	21	−17.0 to −11.0	Trouble in MON winding of OUT coil.	Proceed with test G.
G	1,000	0	REC	TEL binding posts (note 4).	20	8	0	4	21	−8.0 to −4.0	Trouble in TALK key	No trouble.
H	1,000	0	REC	Terms 1 and 2 of OUT coil on CH1 panel (note 5).	20	8	0	4	21	−5.0 to −2.0	Proceed with test I	Trouble in MEAS on TALK keys, coil H, capacitors A, B, or C, or resistor A.
I	1,000	0	REC	Terms 3 and 4 of REC filter on CH1 panel (note 5).	20	8	0	4	21	−12.0 to −7.0	Proceed with test J	Trouble in voice-frequency amplifier or 14.4 db pad.
J	1,000	+6	REC	Terms 3 and 4 on EQL panel. Disconnect pair of wires to AMP panel.	20	15	0	4	21	−38.5 to −35.5	Trouble in EQL, R coil or capacitors R, C, or D.	Trouble in REC AMP, REC filter, or 10-db pad and REC LEV key.

NOTES

1. Record actual reading which is referred to as A in tests B and C.

2. This reading is made on lower scale of meter on measuring panel. On measuring panel operate key to REC position and set selector switch on position 1.

3. This reading is made on upper scale of meter on measuring panel. On measuring panel set switch on position 2W and operation key to MEAS position on CH1 panel.

4. Operate key on channel 1 panel to MON position for test F and TALK position for test G.

5. Remove external wiring from terminals before connecting measuring set.

Table XL.—Transmission measuring tests, channel 1 receiving, Telephone Terminal CF–1–B

Test	Input		Connect oscillator to binding posts	Connect measuring set to—	CHAN 1, 2-WIRE–4-WIRE key	Equalizer dial settings				Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)				MILES	1	4	2	Channel 1 GAIN dial			
A1 (notes 1, 2).	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−8.0 to −4.0	Proceed with test G.	Proceed with test A2.
A2	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	0	8	0	4	21	A+1.0 to A+3.0	Trouble in MILES, dial or dial circuit.	Proceed with test B.
B	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	18	0	4	21	A+9.0 to A+11.0	Trouble in dial 1 or dial 1 circuit.	Proceed with test C.
C1	300	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A−5.0 to A−0.5	Trouble in REC filter, receiving or channel amplifiers, equalizers, or wiring.	Proceed with test D.
C2	2,700	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A−3.5 to A+1.0		
D (note 3)	1,000	0	REC	CH1 4W RECEIVING binding posts.	4-WIRE	20	8	0	4	21	A+1.0 to A+1.5	Trouble in 2-WIRE–4-WIRE key or in wiring to CH1 4W RECEIVING binding posts.	Proceed with test E.
E1	1,000	0	REC	CH1 4W RECEIVING binding posts.	4-WIRE	20	8	0	4	21	D−2.5 to D (note 4).	Trouble in telephone circuit, 2-WIRE–4-WIRE, TALK-MON, or TEL keys.	Proceed with test H.
E2	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A−2.5 to A (note 5).		
E3	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A–1.5 to A (note 6).		
F1	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−1.0 to +2.0 (note 7).	Trouble in measuring circuit or wiring.	Proceed with test G.
F2	1,000	0	REC	CH1 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−8.0 to −4.0 (note 8).		
G (note 9).	1,000	+6	REC	Term punchings 3 and 4 on left rear equalizer panel.	2-WIRE	20	15	0	4	21	−38.5 to −35.5	Trouble in repeat coil R, equalizer, wiring or defective carbon block protectors.	Proceed with test H.
H (note 9).	1,000	0	REC	Terms 3 and 4 of REC filter on CH 1 panel.	2-WIRE	20	8	0	4	21	−12.0 to −7.0	Trouble in receiving amplifier, REC LEV pad or key, REC filter, or wiring.	Proceed with test I.
I (note 9).	1,000	0	REC	Terms 1 and 2 of OUT transformer on CH 1 panel.	2-WIRE	20	8	0	4	21	−5.0 to −1.0	Trouble in channel 1 amplifier or panel wiring.	Trouble in TALK-MON, MEAS, or 2 WIRE-4WIRE keys or hybrid coil H.

NOTES

1. REC LEV, TALK-MON, and MEAS keys should be normal unless otherwise specified.

2. Record actual reading which is referred to as A in tests A2, B, C1, C2, D, E2, and E3.

3. Record actual reading which is referred to as D in test E1.

4. Operate channel 1 TALK-MON key to TALK, TEL key to 4W EXT. Operate key on handset. After noticing measuring set reading, disconnect oscillator and, with transmitter key operated, whistle into transmitter and note that a reading is obtained on measuring set connected to CH1 4W RECEIVING binding posts.

5. Operate channel 1 TALK-MON key to TALK, TEL key to LINE OR 2W SWBD. Note that tone is heard in receiver.

6. Operate channel 1 TALK-MON key to MON, TEL key to LINE OR 2W SWBD. Note that tone heard in receiver is less than in test E2.

7. This reading is made on meter on measuring panel. Operate key on measuring panel to REC and selector switch to position 1. Read meter on lower scale.

8. Reading is made on meter on measuring panel. Operate MEAS key on channel 1 panel. Turn switch on measuring panel to NET LOSS position Read meter on upper scale.

9. Remove wiring from terminals to which measuring set is connected before connecting measuring set.

Table XLI.—Transmission measurement tests, channels 2, 3, and 4 receiving, Telephone Terminal CF–1–A

Test	Input: Frequency (cycles) CH 2	CH 3	CH 4	Power (dbm)	Connect oscillator to binding posts	Connect measuring set to—	Equalizer dial settings: MILES	1	4	2	GAIN	Output power (dbm)	If limits are not met	If limits are met
A	4,900	7,850	10,800	0	REC	CH2, 3, or 4 binding posts.	20	8	0	4	21	−9.0 to −3.0 (note 1).	Proceed with test H.	Proceed with test B.
B	4,900	7,850	10,800	0	REC	CH2, 3, or 4 binding posts.	20	18	0	4	21	A+9.0 to A+11.0	Trouble in line or channel amplifier or demodulator.	Proceed with test C.
C1	5,600	8,500	11,500	0	REC	CH2, 3, or 4 binding posts.	20	8	0	4	21	A−10.0 to A+1.0	Trouble in REC 1–REC 2 filters, channel amplifiers, or channel oscillator frequency.	Proceed with test D.
C2	3,250	6,250	9,250	0	REC	CH2, 3, or 4 binding posts.	20	8	0	4	21	A−6.0 to A+1.0		
D	4,900	7,850	10,800	0	REC	CH2, 3, or 4 binding posts.	20	8	0	4	21	−2.0 to +2.5 (note 2).	Trouble in measuring circuit.	Proceed with test E.
E	4,900	7,850	10,800	0	REC	CH2, 3, or 4 binding posts.	20	8	0	4	21	−9.0 to −3.0 (note 3).	Trouble in measuring circuit.	Proceed with test F.
F	4,900	7,850	10,800	0	REC	TEL binding posts (note 4).	20	8	0	4	21	−17.0 to −9.0	Trouble in MON key or coil OUT.	Proceed with test G.
G	4,900	7,850	10,800	0	REC	TALK binding posts (note 4).	20	8	0	4	21	−9.0 to −3.0	Trouble in TALK key.	No trouble indicated.
H	4,900	7,850	10,800	0	REC	Terms 1 and 2 of OUT coil on CH 3 or CH 4 panel (note 5).	20	8	0	4	21	−6.5 to −0.5	Proceed with test I.	Trouble in MEAS or TALK keys coil H capacitor A, B, or C, or resistor A.
I	4,900	7,850	10,800	0	REC	Terms 4 and 5 of REC 2 filter on CH 2, CH 3, or CH 4 panel (note 5).	20	8	0	4	21	−27.5 to −21.0	Proceed with test J	Trouble in channel amplifier.
J	4,900	7,850	10,800	0	REC	Terms 3 and 4 of REC 1 filter on CH 2, CH 3, or CH 4 panel (note 5).	20	8	0	4	21	−14.0 to −7.5	Proceed with test K.	Trouble in demodulator, REC 2 filter or 4.2-db pad.
K	4,900	7,850	10,800	0	REC	Terms 3 and 4 on equalizer panel. Disconnect the pair of wires to the amplifier panel.	20	15	0	4	21	−38.0 to 35.0	Trouble in EQL, R coil or R, C, or D capacitors.	Trouble in REC 1 filter, 10-db pad or key, or REC amplifier.

NOTES

1. Record actual reading which is referred to as A in tests B, C1, and C2.
2. This reading is made on lower scale of meter on measuring panel. On measuring panel operate key to REC position and set selector switch as follows:
   For channel 2—position 2.
   For channel 4—position 4.
   For channel 3—position 4.
3. This reading is made on upper scale of meter on measuring panel. On measuring panel set selector switch to position 2W and on channel panel under test operate key to MEAS position.
4. Operate key on channel panel to MON position for test F and to TALK position for test G.
5. Remove external wiring from terminals before connecting measuring set.

(Notes for Table XLII)

1. REC LEV key and channel TALK-MON keys should be normal unless otherwise indicated.
2. Record actual reading obtained in test A which is referred to as A in tests B, C1, C2, D, E2, and E3.
3. Record actual reading which is referred to as D in test E1.
4. Operate channel 2, 3, or 4 TALK-MON key to TALK, TEL key to 4W EXT, and operate key on handset. After noting measuring set reading, disconnect oscillator. With handset key operated, whistle into transmitter and note that a reading is obtained on measuring set connected to CHANNELS-4W RECEIVING binding posts.
5. Operate channel 2, 3, or 4 TALK-MON key to TALK, TEL key to LINE or 2W SWBD. Note that tone is heard in receiver.
6. Operate channel 2, 3, or 4 TALK-MON key to MON, TEL key to LINE or 2W SWBD. Note that tone heard in receiver is less than that in test E2.
7. Reading is made on meter on measuring panel. Operate key on measuring panel to REC and turn selector switch to 2, 3, or 4 to measure panels 2, 3, and 4 respectively. Read meter on lower scale.
8. Reading is made on meter on measuring panel. Operate MEAS key on channel panel under test. Turn selector switch on measuring panel to NET LOSS position. Read meter on upper scale.
9. Remove wiring from terminals to which measuring set is connected before connecting measuring set.

Table XLII.—Transmission measurement tests, channels 2, 3, and 4 receiving, Telephone Terminal CF-1-B

Test	Input: Frequency (cycles) CH 2	CH 3	CH 4	Power (dbm)	Connect oscillator to binding posts	Connect measuring set to—	Channel 2-WIRE–4-WIRE key	Equalizer dial settings: MILES	1	4	2	Channel GAIN dial	Output power (dbm)	If limits are not met	If limits are met
A (notes 1, 2).	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−9.5 to −3.0	Proceed with test G.	Proceed with test B.
B	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	18	0	4	21	A+9.0 to A+11.0.	Trouble on dial 1 or dial 1 circuit.	Proceed with test C.
C1	5,600	8,500	11,500	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A−10.0 to A+1.0.	Trouble in REC 1 or REC 2 filters, line or channel amplifiers, or channel oscillator.	Proceed with test D.
C2	3,250	6,250	9,250	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A+6.5 to A+1.0.		
D	4,900	7,850	10,800	0	REC	CH2, 3, or 4 4W RECEIVING binding posts.	4-WIRE	20	8	0	4	21	A−1.0 to A+1.5 (note 3).	Trouble in channel 2WIRE-4WIRE key or in wiring to CHANNELS-4W RECEIVING binding posts.	Proceed with test E.
E1	4,900	7,850	10,800	0	REC	CH 2, 3, or 4 4W RECEIVING binding posts.	4-WIRE	20	8	0	4	21	D to D−2.5 (note 4).	Trouble in telephone circuit, 2 WIRE-4 WIRE, TALK-MON or TEL.	Proceed with test F.
E2	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A to A−2.5 (note 5).		
E3	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	A to A−1.5 (note 6).		
F1	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−2.0 to +2.5 (note 7).	Trouble in measuring circuit.	Proceed with test G.
F2	4,900	7,850	10,800	0	REC	CH2, 3, or 4 2W OR 4W TRANSMITTING binding posts.	2-WIRE	20	8	0	4	21	−9.5 to −3.0 (note 8).		
G (note 9).	4,900	7,850	10,800	+6	REC	Terminal punching 3 and 4 on left rear of equalizer panel.	2-WIRE	20	15	0	4	21	−38.0 to −35.0.	Trouble in repeat coil R, equalizer, or wiring, or defective carbon block protector.	Proceed with test H.
H (note 9).	4,900	7,850	10,800	0	REC	Terms 3 and 4 of REC 1 filter on CH2, 3, or 4 panel.	2-WIRE	20	8	0	4	21	−14.0 to −7.5	Trouble in receiving amplifier, REC 1 filter, REC LEV pad or key, or wiring.	Proceed with test I.
I (note 9)	4,900	7,850	10,800	0	REC	Terms 4 and 5 of REC 2 filter on CH 2, 3, or 4 panel.	2-WIRE	20	8	0	4	21	−27.5 to −21.0	Trouble in channel demodulator or REC 2 filter.	Proceed with test J.
J	4,900	7,850	10,800	0	REC	Terms 1 and 2 or OUT transformer on CH 2, 3, or 4 panel.	2-WIRE	20	8	0	4	21	−6.5 to 0	Trouble in channel amplifier.	Trouble TALK MON, MEAS, or 2 WIRE-4 WIRE keys, hybrid coil H, or wiring.

(See notes on opposite page)

Table XLIII.—Transmission measurement tests, repeater CF–3–A

Test	Input		Equalizer dial settings				Connect oscillator to binding posts	Connect measuring set to binding posts	Output power (dbm)	If limits are not met	If limits are met
	Frequency (cycles)	Power (dbm)	MILES	1	4	2					
A	1,000	0	20	9	4	4	AB IN (note 5)	AB OUT	−0.5 to +2.5 (note 1).	Trouble in AB IN or AB OUT coils, AB EQL, or AB amplifier.	Proceed with test B.
B	1,000	0	20	29	4	4	AB IN (note 5)	(Note 2)	A−1.0 to A+1.0	Trouble in AB amplifier	Proceed with test C.
C	300	0	20	9	4	4	AB IN	AB OUT	A−5.0 to A	Trouble in AB EQL, AB amplifier, AB IN, or AB OUT coils.	Proceed with test D.
	4,900	0	20	9	4	4	AB IN		A 2.0 to A+3.0		
	10,800	0	20	9	4	4	AB IN (note 5)		A+2.0 to A+5.0		
D	1,000	(Note 3)	20	9	4	4	AB IN	AB OUT	+0.5 to +3.5 (note 4).	Trouble in MEAS circuit	Proceed with test E.
	10,800	(Note 3)	20	9	4	4	AB IN		−1.0 to +2.0 (note 4).		
	4,900	(Note 3)	20	9	4	4	AB IN		−0.5 to +2.5 (note 4).		
	7,850	(Note 3)	20	9	4	4	AB IN (note 5)		−1.5 to +1.5 (note 4).		
E	1,000	(Note 3)	20	9	4	4	AB IN (note 5)	AB OUT	+0.5 to +3.5 (note 4).	Trouble in OUTPUT key or associated pad circuit.	Proceed with test F.
F	1,000	(Note 3)	20	14	4	4	AB IN (note 6)	AB OUT	+0.5 to +3.5 (note 4).	Trouble in OUTPUT key or associated pad circuit.	Proceed with test G.
G	1,000	(Note 3)	20	19	4	4	AB IN (note 7)	AB OUT	+0.5 to +3.5 (note 4).	Trouble in OUTPUT key or associated pad circuits.	No trouble indicated.
H	Repeat tests A to D in the other direction of transmission, using the BA instead of the AB designations.										

NOTES

1. Record meter reading which is referred to as A in tests B and C.
2. For this measurement connect binding posts AB OUT to input of attenuator and connect output of attenuator to measuring set. Set attenuator for a loss of 20 db.
3. Adjust input to repeater until output as read on measuring set is 0 dbm.
4. This reading is made on lower scale of meter located on measuring panel. Operate key on measuring panel to AB position and set selector switch as follows:
   For 1,000-cycle input—position 1.
   10,800-cycle input—position 4.
   4,800-cycle input—position 2.
   7,850-cycle input—position 3.
5. For this measurement OUTPUT key should be on NORMAL position
6. For this measurement OUTPUT key is operated to +5 position.
7. For this measurement OUTPUT key is operated to +10 position.

Table XLIV.—Tests for transmission characteristics of filters, Telephone Terminal CF–1–(*)

Equipment designation	Panel location	Input		Connect oscillator to terminals	Connect measuring set to terminals	Output power (dbm)
		Frequency (cycles)	Power (dbm)			
TRSG or REC	CH 1	1,000	0	3–4	1–2	−0.7 to 0
		2,500	0			−2.5 to 0
		3,300	0			−45 or lower
TRSG 1	CH 2, CH 3, or CH 4	1,000	0	4–5	1–3	−0.5 to 0
		2,500	0			−0.7 to 0
		5,300	0			−18 or lower
TRSG 2 or REC 1	CH 2	2,900	0	3–4	1–2	−18 or lower
		3,500	0			−2.0 to 0
		5,000	0			−2.5 to 0
		6,300	0			−45 or lower
TRSG 2 or REC 1*	CH 3	5,500	0	3–4	1–2	−45 or lower
		6,500	0			−4.0 to 0
		8,000	0			−4.0 to 0
		9,300	0			−45 or lower
TRSG 2 or REC 1*	CH 4	8,500	0	3–4	1–2	−45 or lower
		9,500	0			−6.0 to −2.0
		11,000	0			−6.0 to −2.0
		12,500	0			−45 or lower
TRSG 2 or REC 1	CH 3	5,500	0	3–4	1–2	−45 or lower
		6,500	0			−2.5 to 0
		8,000	0			−2.5 to 0
		9,300	0			−45 or lower
TRSG 2 or REC 1	CH 4	8,500	0	3–4	1–2	−45 or lower
		9,500	0			−5.0 to −1.0
		11,000	0			−5.0 to −1.0
		12,500	0			−45 or lower

Table XLIV.—Tests for transmission characteristics of filters, Telephone Terminal CF–1–(*)—Continued

Equipment designation	Panel location	Input		Connect oscillator to terminals	Connect measuring set to terminals	Output power (dbm)
		Frequency (cycles)	Power (dbm)			
REC 2	CH2, CH 3, or CH 4	1, 000	0	1–3	4–5	−1.5 to 0
		2, 000	0			−1.5 to 0
		3, 100	0			−18 or lower
	TALK–( ) MON	1, 000	0	9–10	10–11	−1.0 to 0
		2, 500	0			−7.0 to −0.5
		4, 000	0			−30 or lower
	TALK–( ) MON	1, 000	0	2–3	1–2	−1.0 to 0
		2, 500	0			−7.0 to −0.5
		4, 000	0			−30 or lower

Note.—Remove external wiring from terminals before connecting measuring set.
*Filters furnished with later models.

Table XLV.—Tests for transmission characteristics of gain control equalizers, Telephone Terminal CF–1–(*)

Input		Equalizer dial settings				Connect oscillator to terminals	Connect measuring set to terminals	Output power (dbm)
Frequency (cycles)	Power (dbm)	MILES	1	4	2			
1, 000	+6	0	15	0	4	1–2 on equalizer panel (note 4).	3–4 on equalizer panel (note 4).	−36.0 to −33.0.
1, 000	+6	0	30	0	4	NOTE.—Oscillator connections apply for each test.	NOTE.—Measuring set connections apply for each test.	−21.0 to −18.0 (note 1.)
10, 800	+6	0	30	0	4			−21.0 to −17.0.
10, 800	+6	0	30	14	4			−7.0 to −3.0 (note 2).
4, 900	+6	0	30	0	0			−25.0 to −21.5.
4, 900	+6	0	30	0	8			−17.0 to −13.5 (note 3).
300	+6	0	30	0	4			−22.0 to −18.5.
300	+6	10	30	0	4			−25.5 to −22.0.
300	+6	20	30	0	4			−26.0 to −22.5.
300	+6	30	30	0	4			−26.0 to −22.5.

NOTES

1. Output should increase between 0.75 and 1.25 db for each step increase in setting of dial 1.
2. Output should increase between 0.75 and 1.25 db per each step increase in setting of dial 4.
3. Output should increase between 0.75 and 1.25 db for each step increase in setting of dial 2.
4. Remove external wiring from terminals before connecting measuring equipment.

Table XLVI.—Tests for transmission characteristics for trouble locations of channel amplifiers and oscillators, Telephone Terminal CF–1–A

Circuit designation	Type of test	Input		Connect oscillator to—	Connect measuring set to	Output power (dbm)
		Frequency (cycles)	Power (dbm)			
Voice-frequency amplifier CH 1, CH 2, CH 3, CH 4.	Gain	1, 000	−20	(Note 1)	CH 1, 2, 3, or 4 binding posts.	−4.5 to −2.0 (note 2).
		300	−20			B−1.0 to B+1.0.
		2, 700	−20			B−1.0 to B+1.0.
		1, 000	−30			B−2.0 to B+2.0.
		1, 000	−50			B−14.0 to B−2.0.
Channel oscillator CH 2	Oscillator power				Terms 1 and 2 of C coil (note 3).	−4.0 to +2.0.
Channel oscillator CH 3	Oscillator power				Terms 1 and 2 of C coil (note 3).	−3.0 to +3.0.
Channel oscillator CH 4	Oscillator power				Terms 1 and 2 of C coil (note 3).	−2.0 to +4.0.

NOTES

1. Remove wires between AA and AB resistors and REC 2 filter or 14.4-db pad. Connect oscillator to AA and AB resistors.
2. Record actual values of reading which is referred to as B in the balance of the gain tests. Set GAIN dial on channel panels as follows:
When input power is −20 dbm, set GAIN dial on step 20.
When input power is −30 dbm, set GAIN dial on step 30.
When input power is −50 dbm, set GAIN dial on step 45.
3. Do not remove any wires from terminals 1 and 2 of C coil.

Table XLVII.—Tests for transmission characteristics of channel amplifiers and oscillators, Telephone Terminal CF–1–B

Circuit designation	Type of test	Input		Connect oscillator to—	Connect measuring set to	Output power (dbm)
		Frequency (cycles)	Power (dbm)			
Voice-frequency amplifier CH 1, CH 2, CH 3, CH 4.	Gain	1,000	−20	(Note 1)	CH 1, 2, 3, or 4 2W OR 4W TRANSMITTING binding posts (note 4).	−4.5 to −2.0 (note 2).
		300	−20			B−1.0 to B+1.0.
		2,700	−20			B−1.5 to B+1.0.
		1,000	−30			B−2.0 to B+2.0.
		1,000	−50			B−16.0 to B−2.
Channel oscillator CH 2	Oscillator power				Terms 1 and 2 of C coil (note 3).	−4.0 to +2.0.
Channel oscillator CH 3	Oscillator power				Terms 1 and 2 of C coil (note 3).	−3.0 to +3.0.
Channel oscillator CH 4	Oscillator power				Terms 1 and 2 of C coil (note 3).	−2.0 to +4.0.

NOTES

1. Remove wires between resistors AA and AB and REC 2 filter or 14.4-db pad. Connect oscillator to resistors AA and AB.
2. Record actual value of reading which is referred to as B in balance of tests. Set GAIN dial on channel panels as follows:
   When input power is −20 dbm, set GAIN dial on step 20.
   When input power is −30 dbm, set GAIN dial on step 30.
   When input power is −50 dbm, set GAIN dial on step 45.
3. Do not remove any wires from terminals 1 and 2 of C coil.
4. Channel 2 WIRE–4 WIRE key on 2 WIRE.

Table XLVIII.—Transmission measurements tests, over-all check of terminal (using measuring equipment available at terminal)

Test	Position									Meter reading	If limits are not met	If limits are met
	OUTPUT key	SEND key	MEAS switch	MEAS key	Equalizer dial setting							
					MILES	1	4	2	GAIN			
A	NORMAL	CH1	1	TRSG	0	6	0	4	21	−2.0 to +3.0	Trouble in transmitting branch.	Proceed to test B.
B	+5	CH1	1	TRSG	0	6	0	4	21	−2.0 to −3.0	Trouble in OUTPUT key or in associated networks.	Proceed to test C.
C	+10	CH1	1	TRSG	0	6	0	4	21	−2.0 to −3.0	Trouble in OUTPUT key or in associated networks.	Proceed to test D.
D	NORMAL	CH4	4	TRSG	0	6	0	4	21	−5.5 to +2.0	Trouble in transmitting branch.	Proceed to test E.
E	NORMAL	CH2	2	TRSG	0	6	0	4	21	−4.0 to +2.0	Trouble in transmitting branch.	Proceed to test F.
F	NORMAL	CH3	3	TRSG	0	6	0	4	21	−5.0 to +2.0	Trouble in transmitting branch.	Proceed to test G.
G	NORMAL	CH1	1	REC	0	6	0	4	21	−3.0 to +3.0	Trouble in REC amplifier (note 1).	Proceed to test H.
H	NORMAL	CH4	4	REC	0	6	0	4	21	−5.5 to +1.5	Trouble in REC amplifier (note 1).	Proceed to test I.
I	NORMAL	CH2	2	REC	0	6	0	4	21	−4.0 to +2.5	Trouble in REC amplifier (note 1).	Proceed to test J.
J	NORMAL	CH3	3	REC	0	6	0	4	21	−4.5 to +2.5	Trouble in REC amplifier (note 1).	Proceed to test K.
K	NORMAL	CH1 (note 3)	2W	CH 1 MEAS	0	6	0	4	21	−10.0 to −3.0	Trouble in CH 1 REC (note 2).	Proceed to test L.
L	NORMAL	CH2	2W	CH 2 MEAS	0	6	0	4	21	−10.0 to −3.0	Trouble in CH 2 REC (note 2).	Proceed to test M.
M	NORMAL	CH3	2W	CH 3 MEAS	0	6	0	4	21	−11.5 to −3.5	Trouble in CH 3 REC (note 2).	Proceed to test N.
N	NORMAL	CH4	2W	CH 4 MEAS	0	6	0	4	21	−13.0 to −5.0	Trouble in CH 4 REC (note 2).	No trouble indicated.

NOTES

1. Tests G, H, I, and J assume limits were met for tests A through E.
2. Tests K, L, M, and N assume limits were met for tests A through H.
3. Repeat test K with terminal operating on 12-volt battery by disconnecting the a-c supply from the terminal.

Table XLIX.—Transmission measurement tests, check of repeater using a terminal (using measuring equipment available at terminal and repeater)

Test	Position					Output power (dbm)	If limits are not met	If limits are met
	Terminal		Operate repeater					
	SEND key	OUTPUT key	Switch key	OUTPUT key	MEAS key			
A	CH 1	NORMAL	1	NORMAL	AB (note 1)	−1.0 to +5.0	Trouble in AB amplifier branch or repeater measuring circuit.	Proceed to test B.
B	CH 4	NORMAL	4	NORMAL	AB (note 1)	−5.0 to +3.0	Trouble in AB amplifier branch	Proceed to test C.
C	CH 2	NORMAL	2	NORMAL	AB (note 1)	−2.5 to +4.0	Trouble in AB amplifier branch	Proceed to test D.
D	CH 3	NORMAL	3	NORMAL	AB (note 1)	−4.5 to +2.5	Trouble in AB amplifier branch	Proceed to test E.
E	CH 1	NORMAL	1	NORMAL	BA (note 1)	−0.5 to +6.0	Trouble in BA amplifier branch	Proceed to test F.
F	CH 4	NORMAL	4	NORMAL	BA (note 1)	−5.0 to +3.5	Trouble in BA amplifier branch	Proceed to test G.
G	CH 2	NORMAL	2	NORMAL	BA (note 1)	−2.0 to +5.0	Trouble in BA amplifier branch	Proceed to test H.
H	CH 3	NORMAL	3	NORMAL	BA (note 1)	−4.0 to +4.0	Trouble in BA amplifier branch	Proceed to test I.
I	CH 1	+5	1	+5	AB (note 1)	−1.5 to +5.5	Trouble in repeater OUTPUT key or associated pad.	Proceed to test J.
J	CH 1	+10	1	+10	AB (note 1)	−1.5 to +5.5	Trouble in repeater OUTPUT key or associated pad.	Proceed to test K.
K	CH 1	NORMAL	1	NORMAL	REC (note 2)	−2.0 to +6.0	Trouble in repeater line coil or protectors.	No trouble indicated.

NOTES

1. Read on repeater measuring set meter.
2. Read on terminal measuring set meter.
3. Set equalizer dials for all tests:

Terminal				Repeater			
Miles	1	4	2	Miles	1	4	2
0	6	0	4	0	7	0	4

4. These tests should be made only after checking terminal. (See table XLVII.)

Section XVI. REPAIRS

170. Replacement of Parts

No difficulty should be encountered in the removal and replacement of controls, switches, or other parts on Telephone Terminal CF–1–(*) or Repeater CF–3–A. If a switch requires replacement, carefully mark the wires connected to the switch with tags or other devices so that they can be connected correctly when the new switch is installed. Use this method of identification in all cases where replacement requires disconnecting numerous wires. Consult the wiring diagrams before making any repairs or replacements involving wiring of the equipment.

171. Use of Tools and Repair Equipment

The main considerations when making adjustments, repairs, and replacements are cleanliness, care of tools, accuracy of adjustment, and care in handling the equipment.

a. Keep the apparatus clean at all times. Contact trouble often results from dust and lint between contact surfaces.

b. Be careful not to break wires of the multicontact switches such as GAIN potentiometers, MILES and equalizer dial, switches, and the measuring panel selector switch on Repeater CF–3–A. The GAIN potentiometers and the equalizer dials are in the transmission path, and loose connections or dust and lint on contact surfaces will cause noise in the circuit or an open in the transmission circuit.

c. Keep the dust covers in place to prevent lint from falling on the spring contacts of the relay jacks, or on the contacts of switches.

d. Keep the front and rear covers in place except when working on the equipment.

172. Repair Equipment

No special tools are necessary for repairs. When the tools supplied with Tool Equipment TE–123 are used properly, it is possible to perform all the repairs necessary except the adjustment of relays.

Tools for adjustment of relays are listed in table L and must be ordered separately.

173. Soldering

Be careful when changing wires to avoid the danger of potential wiring troubles. Properly soldered connections are important. A good joint is one which is sound, on which not too much solder has been used. Adjust the clearance of adjacent terminals; vibrations may cause crosses. Bits of wire or solder should not be left between wiring terminals, among the wires, or in the apparatus housing during soldering operations. Protect the apparatus below the soldering operation with cotton duck or similar material. Use a soldering-iron holder to reduce the fire hazard.

174. Relay S

Relay S is used in the alarm and signaling circuit to indicate an interruption in the simplex circuit used for signaling. When the relay operates the bottom contact should close before the armature reaches its back stop. The armature travel, that is, the gap between the armature and the pole face when the relay is released, should not be greater than 0.029 inch. The relay should operate on a current of 0.0071 ampere and should not operate when a current of 0.0045 ampere is suddenly applied. Operation of the relay on its nonoperate current indicates that the tension of the spring is too light, while failure to operate on its operate current indicates that the tension is too great.

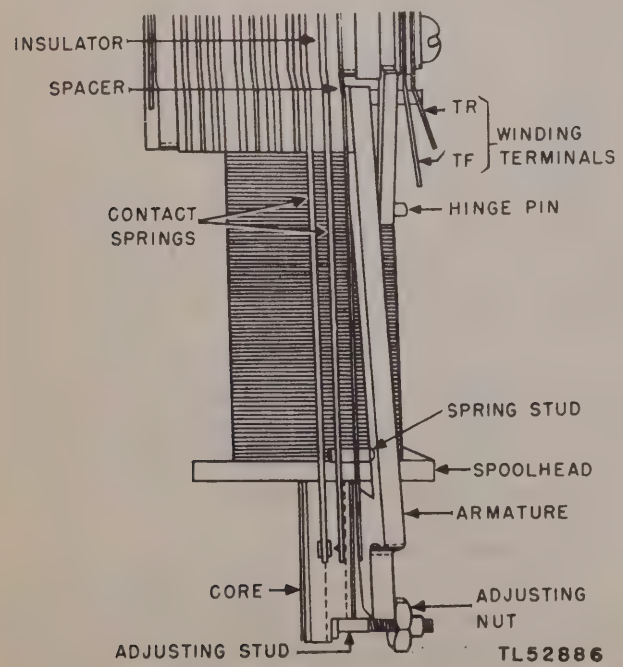

Figure 73. Relay S, top view.

a. Mechanical Requirements and Adjustments. (1) Relay S is a quick-acting relay equipped with twin sets of contacts on each pair of mating springs. One pair is split near the contact to permit setting the contacts so that both pairs make and break at approximately the same time. Twin contacts provide parallel contacts which give added protection against failure caused by lint or dirt between the contacts. This is true only when the springs are properly adjusted so that parallel contacting occurs.

(2) The armatures of these relays are not rigidly fastened at the rear but are held in alignment by bearing pins. The armature, as a result, is held loosely in position when relay S is not energized. Therefore the relay must be operated electrically during gauging operations to obtain accuracy of adjustment.

(3) Tools required for adjustment of relay S are not supplied and must be ordered separately.

Table L.—Tools for adjustment of relays

Signal Corps stock No.	WECo code No.	Description
6R41059	259	Spring adjuster.
6R41100	300	Spring adjuster.
6R41163	363	Spring adjuster.
6R41232B	432B	Spring adjuster
6R41274A	474A	Closed end offset wrench, hex., 3/16" x 1/4".
6R41305A	505A	Spring adjuster (for thin springs).
6R41307A	507A	Spring adjuster (for heavy springs).
6Z7360	KS–6320	Orange stick.
6R19016		Cabinet screwdriver, 6".
6R4710–6.5		P long-nose pliers, 6½".
6R40870D or	70D or	5–0–50-gram gauge.
6R40870H	70H	0–30-gram gauge.
6R40933A	133A	Stud gap gauge.
6R40932K	132K	Thickness gauge.
6R40932AF	132AF	Thickness gauge.
6R40932AG	132AG	Thickness gauge.
3F4316 or	D–173231	Test receiver.
3F4316.1		
6N1624		Cloth (lint-free).
6G184.2		Carbon tetrachloride.
3F4181		Test Set I–181, current flow test set.

b. Spring Tension. (1) All springs should be tensioned against the armature. Apply the spring gauge so that its tip engages both prongs of the forked springs. On solid springs apply the tip of the gauge just in front of the contact. Use a 70H or 70J gauge.

(2) Tension of springs marked ARM OPR is measured with the armature in the operated position. Tension of all the other springs is

measured with the armature in the nonoperated position.

(3) The minimum armature back tension, measured as the armature leaves its backstop, is 5.0 grams test and 9.0 grams readjust.

(4) The springs designated A have no definite tension requirement other than that the combined pressures of the top and bottom A springs shall be sufficient to meet the armature back tension requirements given in (3) above.

(5) The minimum tension of B springs, measured as contacts break, is 4.0 grams test and 6.0 grams readjust.

(6) The minimum tension of C springs, measured as the spring tang leaves the spoolhead, is 25 grams test and 30 grams readjust.

c. Spring Tangs. Spring tangs are the offset portions of the springs which rest against the spoolhead. These should be positioned so that the free end extends back of the front face of the spoolhead. The edge of the tang should not rub or bind against the bottom of the slot in which the springs travel.

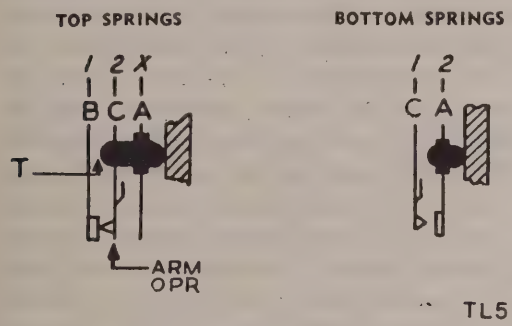

Figure 74. Relay S, spring arrangement.

d. Armature Travel. (1) The armature travel should be as specified below. Use the 132K gauge, placed between the armature and the core. When using the gauge, place the long axis in a horizontal position. (See fig. 75.)

(2) Try to insert the gauge in the armature gap. If the gauge enters, it should enter with a tight fit. Do not force the gauge. Since no minimum limit is specified, the armature travel may be any lesser value consistent with meeting the other requirements.

(3) Turn the adjusting nut with the 474A wrench until friction is felt against the gauge.

e. Stud Gaps. The stud gaps labeled T (fig. 74) should be a minimum of 0.006 inch. Check by slipping the 133A stud gap gauge over the end of the armature, between the armature and the A spring stud. If gauged by eye, the 0.006-inch gap is equivalent to about one-half the thickness of one of the thin A springs of the relay.

f. Contact Separation. The minimum separation between each pair of contacts normally open, or between each pair of contacts that are opened when the relay is electrically operated, should be 0.005 inch. Gauge this separation by eye.

g. Contact Make. At least one of the contact fingers of each pair of mating springs should make when the relay is electrically energized against the 0.006-inch 132AG gauge. Both of the split springs should make when the armature is operated electrically against the 0.004-inch 132AF gauge.

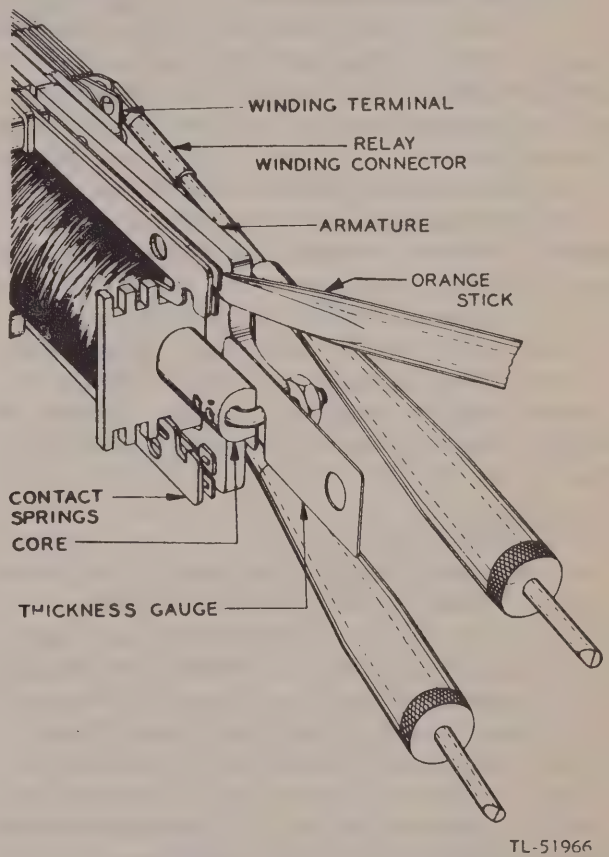

Figure 75. Relay S, method of checking contact make.

h. Adjustment of Springs. (1) The requirements for spring tensions and spring positions of relay S are given in *b* above. The test values apply when the relays are tested. The readjust values should be used when it is necessary to readjust the relay to allow for changes in the adjustments with use.

(2) Use the 505A spring adjuster for the adjustment of the thin springs and the 507A spring adjuster for the heavy springs. Use a 259 adjuster if these are not available. To adjust the position

Table LI.—Test and readjust values for relay S

	Grams	
	Test	Readjust
Minimum armature back tension	5. 0	9. 0
Minimum tension of B spring	4. 0	6. 0

of springs to meet the contact separation, stud gap, and contact make requirements, adjust the spring tangs resting against the spoolhead. Hold the spring with a 507A or 259 spring adjuster placed above the spring tang, and adjust the tang to the right or the left as needed, using a 432B adjuster to accomplish this.

(3) To adjust the tension of a spring, span the spring with the slotted end of the spring adjuster just back of the stud and slide the adjuster back to the base of the spring. Adjust the spring to the right or left, as required. Take care not to disturb the adjacent springs. All springs should be approximately straight, but a slight bow may exist if there is a clearance between adjacent springs in both the nonoperated and the electrically operated position of the relay armature.

(4) Adjust the relative position of the split ends of the contact springs, using the 363 spring adjuster. Adjust the cover retaining springs to secure the cover properly with the 300 spring adjuster.

175. Relay R

a. General. Relay R is used in the power supply circuit to effect the transfer to the emergency 12-volt battery if the regular a-c supply fails. This relay is held operated during regular a-c operation. When the a-c supply fails, the relay releases to close the circuit for the operation of the vibrator G. A different relay R is used in earlier models of the power supply panels as covered in paragraphs 36 and 37. The same voltage test limits apply to both relays, but the procedure if the relay fails to operate is different.

(1) The relay should operate on a power supply voltage of 105 volts when the power supply circuit is wired for 110- to 125-volt operation, and on a voltage of 210 volts when arranged for 220- to 250-volt operation. If the relay does not release when the voltage is disconnected, a check for binding of the armature should be made. (See *b* below.)

(2) If the relay R used in later models of the power supply panel fails to operate, disconnect the a-c supply. Disconnect one of the leads from the relay to the rectifier by removing the screw holding the terminal connected to the lead from the relay. The armature gap, contact spring, and armature restoring spring should then be adjusted (*c* and *d* below) until the relay operates satisfactorily on 15 volts ±½-volt direct current when cold, or 18 volts ±½-volt when hot. If the relay fails to operate on a voltage of between 105 to 125 volts, it indicates trouble in transformer T1, varistor V5, or wiring trouble.

(3) If the relay R used in earlier models of the power supply panel fails to operate, disconnect it from the circuit and apply 207 volts directly across the windings. Adjust the armature gap, contact spring, and armature restoring spring (*c* and *d* below) until the relay operates satisfactorily. If the relay fails to operate on a supply voltage of between 105 and 125 volts, capacitor K should be replaced.

b. Check of Operation. (1) Check the operation of relay R occasionally to see that it is in operable condition. Since the relay will be held operated a greater part of the time, the most likely cause of failure will be the accumulation of dirt or lint on the contacts which close when the power is removed from the relay. The left-hand set of contacts causes vibrator G to operate. The right-hand set of contacts closes the circuit through transformer T. To check the relay, see that the 12-volt battery is connected to the storage battery cord of the power supply panel. Remove the a-c power supply cord from the convenience outlet. Relay R should release, the vibrator should start to operate, and normal power supply voltages should be provided to the terminals or repeater. If vibrator G does not start, or if proper output voltages are not obtained from the power supply panel, check to see that the armature is fully released, is not binding, and that the contacts are properly closed.

(2) If the relay is not released fully because of binding, clean the bearing points of the armature by applying a small amount of carbon tetrachloride. If the armature tends to stick against the pole piece, clean the armature and the pole-piece surfaces with a cloth and carbon tetrachloride. If, after cleaning, the relay does not release fully and does not provide reasonably solid closure of the contacts, the armature restoring spring may require further tensioning. Adjust it by turning the knurled adjusting screw at the center front of the relay with the fingers. Do not increase the tension to a point where the relay will not operate properly. The relay should operate with a snap

immediately upon reconnection of the a-c power cord.

(3) If the relay contacts rest together with a reasonable pressure but the circuit does not operate properly, check the contacts by bridging them with D–173231 test set (test receiver). When properly made contacts are bridged with the test receiver there will be no apparent click. A click will be heard when improperly made contacts are bridged. Clean the contacts by drawing a strip of crocus cloth, such as that provided with Tool Equipment TE–123, between the contacts with the contacts pressed firmly together.

(4) If the relay does not operate properly on the a-c supply, make a check of the circuit as follows:

(*a*) Determine that a proper a-c supply voltage is received at the power panel. This voltage should be a minimum of 105 volts when the power panel circuit is wired for 100- to 125-volt operation, and a minimum of 210 volts when the circuit is wired for 220- to 250-volt operation.

(*b*) If the relay does not operate with the proper power supply voltage, check to see that at least 18-volts direct current are measured across the bottom left and bottom right (winding) terminals of relay R. Use the 30-volt d-c scale of the voltohmmeter.

(*c*) If the voltage measured at that point is less than 18 volts, measure the a-c voltage across terminals 5 and 6 of transformer T1, using the 30-volt a-c scale of the voltohmmeter. This voltage should be at least 23 volts.

(*d*) If sufficient voltage is measured at the windings of transformer T1 and not at relay R, trouble is indicated in the connections to or in varistor V5.

(*e*) If proper voltage is not measured at the terminals of transformer T1, check for wiring trouble in the transformer.

(*f*) If voltages measured are satisfactory, but the relay does not operate properly, proceed with the adjustments in *b* below.

c. Adjustment of Armature Restoring Spring. If the relay fails to release or to operate properly and it has been cleaned (*a* above), some correction may be made by adjustment of the armature restoring spring which is controlled by the knurled knob at the front center of the relay. Adjust this so that, with average or minimum power supply voltage supplied to the terminal or repeater, the relay will operate reliably with a 20-ohm resistor connected in series with the windings. It should release reliably when the a-c power supply is disconnected.

(1) To connect such a resistor for test, disconnect both the a-c and d-c power supplies from the power panel.

(2) Disconnect the black lead from the lower right terminal of relay R by removing screw holding the wire to the relay with the 3-inch H-cabinet screw driver of Tool Equipment TE–123.

(3) Connect the 20-ohm (minimum 1 watt) resistor between the lower right terminal of the relay and the wire just removed from it. Reconnect the a-c power cord to the a-c supply.

(4) Adjust the knurled screw at the front of the relay until reliable operation is obtained each time that the power supply is connected and reliable release is obtained when the a-c power supply is disconnected.

d. Adjustment of Contact Springs and Armature Gap. If it is not possible to obtain reliable adjustment by adjustment of the armature restoring spring (*b* above), remove the relay from the panel to obtain proper access to its parts. Disconnect the a-c and d-c power connections to the power panel, disconnect all wires to the relay, and remove the four relay mounting screws using H-cabinet screw driver. With relay R removed from the power panel the following corrections may be applied:

(1) Using the 70H gauge in Tool Equipment TE–123, check to see that the contact pressure measured near the ends of the contact springs is a minimum of 18 grams for each contact when the relay is not operated and a minimum of 10 grams for each contact spring when the armature is held fully operated. Readjust the springs as required, using the KS–7782 pliers supplied with Tool Equipment TE–123 to readjust spring tensions. Apply the pliers at the base of the contact springs.

(2) With the relay removed from the mounting, test battery may be obtained from a heavy duty dry cell or other source adjustable to 15 $\pm$½ volts and capable of supplying approximately 0.2 ampere. The relay should operate on this voltage and should not operate when 13½$\pm$½ volts are connected. If the relay operates but the armature does not pull up to the core, it is an indication of excessive contact spring tension or of excessive armature restoring spring tension. If the armature does not move from its unoperated position when 15 volts are applied, the excessive restoring spring tension or too great a nonoperated armature gap may be the cause.

(3) The armature gap may be controlled by the adjusting screw at the right lower front of the relay. The ⅜-inch open-end wrench supplied

with Tool Equipment TE–123 may be used for loosening or tightening the locknut of this screw. Use the ⅛-inch tip screw driver for turning the adjusting screw.

(4) If the relay fails to meet its nonoperate requirement, increase the armature gap.

(5) In some cases the restoring spring may become damaged to the extent that it will not permit proper operation of the relay. In such cases, the relay should be replaced and returned for repair.

176. Replacement of Fuse Holders

If fuse failure is caused by defective 1 AMP AC or 1 AMP AC1 fuse holders, replace the fuse holders in the following manner:

a. Power Supply A Panel of Telephone Terminal CF–1–(*) or Power Supply Panel of Repeater CF–3–A.

(1) Remove the front cover of the power supply panel.

(2) Loosen the screw on the cable clamp fastening the a-c cord.

(3) Remove the two 6–32 machine screws fastening the L-bracket of the fuse holder to the upper left-hand edge of the power unit.

(4) Unsolder the wires and remove the nut from the fuse holder. Withdraw the fuse holder.

(5) Replace the fuse holder, resolder the leads, and replace the front cover.

b. Power Supply B Panel of Telephone Terminal CF–1–(*). (1) Remove the front cover of the power supply panel.

(2) Loosen the screws on the cable clamp fastening the a-c cord.

(3) Remove the screws fastening the power supply to the bay stretcher.

(4) Pull the power supply unit forward 2 or 3 inches. Remove the two 6–32 machine screws fastening the fuse holder L-bracket to the upper left-hand edge of the power unit.

(5) Unsolder the wires and remove the nut from the fuse holder. Withdraw the fuse holder.

(6) Replace the fuse holder and resolder the leads. Return the power supply unit to its original position and replace the cover.

177. Charging Batteries BB–55 from Rectifier RA–83–A

a. When charging Batteries BB–55 from Rectifier RA–83–A, the battery under charge may be left connected to the carrier equipment to provide normal fallback operation. If the a-c power supply fails, the connection Rectifier RA–83–A across the battery will not damage the battery.

b. Start at a rate of 10 amperes. Ten amperes is the maximum capacity of Rectifier RA–83–A at 12 volts. With a constant voltage output of the rectifier the 10-ampere rate will gradually decrease as the battery becomes charged. When the battery is nearly charged the charging current will be about one-half of the initial charging current. If the voltage is near the 11.5-volt limit it will require from 15 to 20 hours to charge the battery. If the voltage is much below 11.5 volts, a few more hours may be required to bring the battery up to full charge.

c. Look at the battery frequently during the first hour or two of the charging period. If there is excessive gassing of the battery or if the electrolyte temperature becomes higher than about 110° F, reduce the charging current.

d. Battery BB–55 is rated at 150 ampere-hours when discharged at a rate sufficient to discharge the battery in 20 hours (150/20=7.5 amperes). If the battery is charged at a 7-ampere rate it normally will require 150/7=21 hours to charge, plus 2 or 3 hours allowance for charging efficiency (usually about 90 percent). When charging is started at the rate of 10 amperes, the time is reduced. Therefore, about 20 hours will be required to bring a battery in good condition up to full charge. (See TM 11–430.) If the battery is in poor condition or is completely discharged, a few more than 20 hours may be required to bring the battery back to full charge.

e. After charging the battery for what is determined to be a sufficient period, disconnect the a-c supply to allow the battery to be placed under load. After 15 minutes, check the voltage again. The voltage should be 12 volts. As the battery ages, the voltage on load drops, and it may not be possible to reach the 12-volt limit.

178. Charging Batteries BB–55 from Power Unit PE–201–(*)

a. The field rheostat on the panel board in the control panel box of Power Unit PE–201–(*) controls the a-c and d-c voltage output for charging 6- and 12-volt batteries. A reverse current relay is provided to prevent a battery on charge from discharging through the a-c winding when the power unit is not in operation. A rheostat on the back of the box controls the d-c output for battery charging.

b. When using the a-c and d-c circuit at the same time, set the controls as follows: Regulate the field rheostat to the determined a-c voltage, then adjust the d-c charging rate with the rheostat

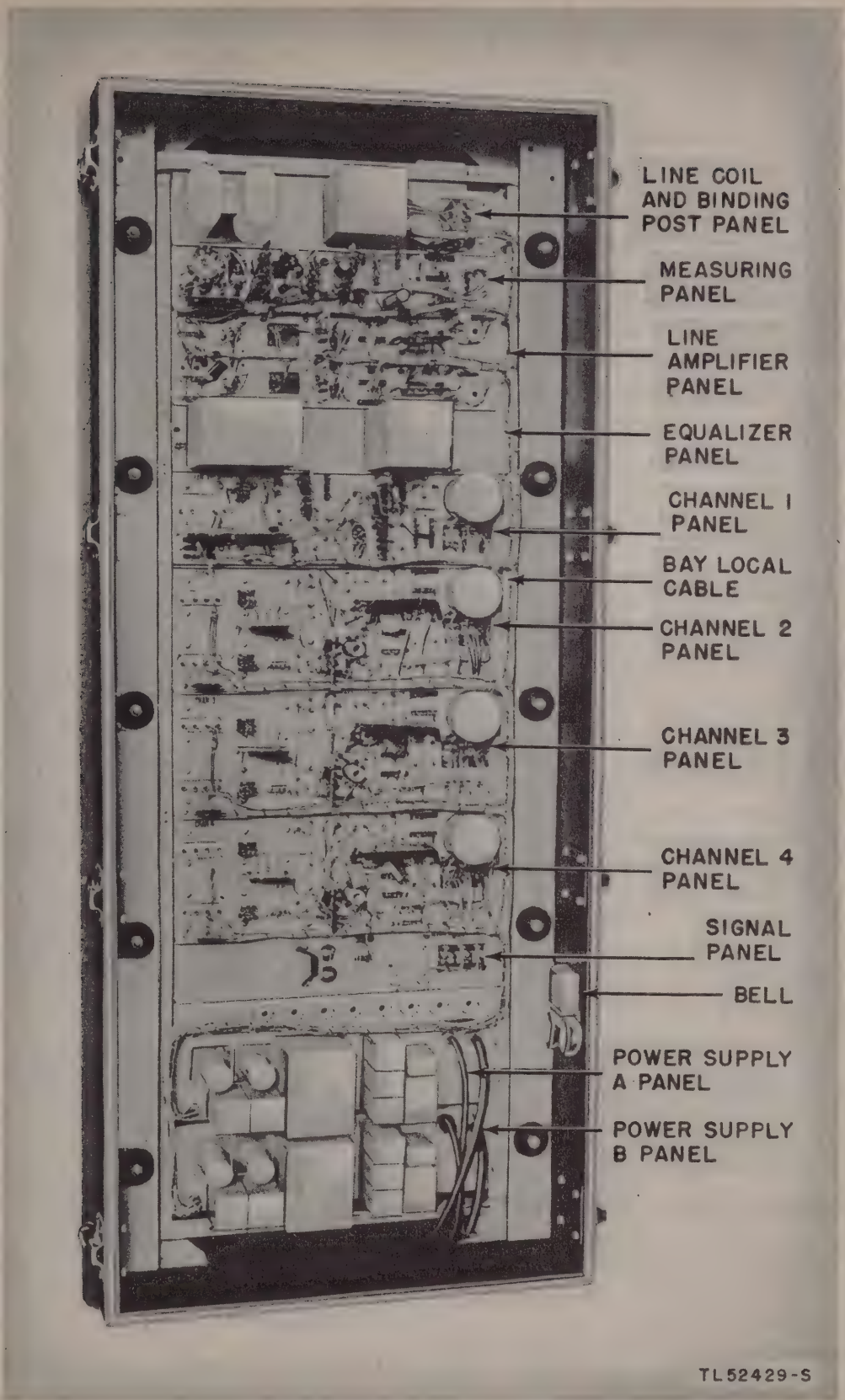

Figure 76. Telephone Terminal CF–1–A, rear view, cover removed.

on the rear side of the panel box. If the d-c load lowers the a-c voltage readjust both rheostats.

c. Start the charge at a rate of 10 amperes. With a constant voltage output, the 10-ampere rate will gradually decrease as the battery becomes charged. It will require from 15 to 20 hours to charge the battery if the voltage is near the 11.5-volt limit. If the voltage is much below 11.5 volts, a few more hours may be required.

d. Inspect the battery frequently during the first hour or two of the charging period. Reduce the charging current if there is excessive gassing or if the temperature of the electrolyte becomes higher than about 110° F.

179. Restoring Film to Electrolytic Capacitors

a. Capacitors B1 and B2. Normal operation of the rectifier in a terminal or repeater is the best means of maintaining the film to capacitors B1 and B2 in the power supply circuit. When this is impracticable, a voltage of 120 to 150 volts direct current in series with a 120-volt lamp should be connected to the power supply panel for at least 30 minutes. Connect the positive terminal of the d-c supply to the ±150-volt output terminal on the power supply panel, and connect the negative terminal of the d-c supply to the GRD terminal.

b. Capacitor T (Telephone Terminal CF–1–B). As in the case of the capacitors in the power supply circuit, normal operation is the best means of maintaining the film to capacitor T in the telephone circuit of Telephone Terminal CF–1–B. Where this is impossible, the film may be restored by connecting a source of 15-volt direct current across the terminals of the capacitors for approximately 30 minutes. Connect the positive terminal of the d-c supply to the R terminal and the negative terminal to the BK terminal of the connecting block to which the handset is connected on the rear of the talk and signal panel. Disconnect the wires from these terminals to the handset before connecting the d-c supply.

180. Oscillator Frequency Adjustment

a. If there is a lack of synchronism between the carrier oscillators of the two terminals (par. 169), make an adjustment of the oscillator frequency at terminal B as follows:

(1) Unscrew the fiber tube associated with input transformer C on the rear of the channel panel under test by turning it once.

(2) Using a screw driver, adjust the screw inside the fiber tube until the number of beats, as read on the meter, is reduced to less than one per second. Tighten the fiber tube after each adjustment.

(3) Measure the frequency as in paragraph 169 by sending 1,000-cycle test power from terminal A on channel 1 and on the channel under test and measuring both tones simultaneously at the receiving terminal.

(4) Make the adjustment at only one terminal since a single oscillator supplies the carrier frequency for both directions of transmission at each terminal. If it is not convenient to make the adjustment at terminal B, measure the beats at terminal B and make the adjustment at terminal A.

b. If there is difficulty in obtaining satisfactory adjustment, adjust the oscillator at the sending terminal to the midfrequency of the selective network.

(1) Throw the lever of the SEND key on the channel panel under test, turning the MEAS switch to the position corresponding to the channel number under test and throwing the measuring set key lever to TRSG.

(2) Adjust the screw inside the fiber tube until the maximum meter deflection is obtained. Test the frequency again. (See par. 169.)

(3) Be careful when making these adjustments. Make a few adjustments to be sure that the final adjustment is close to the midband frequency of the filter. Do this by adjusting the screw inside the fiber tube until the meter indicates the maximum reading and starts to decrease, then turn the screw in the opposite direction until the meter passes the maximum point. Bring the reading back to maximum, and tighten the fiber tube.

181. Repainting

When the finish on the wooden case of the terminal or repeater equipment has been badly scarred or damaged, repaint the case with olive drab semigloss enamel as follows:

a. When a touch-up job is necessary, apply the paint with a brush. Use authorized paint consistent with existing regulations.

b. When numerous scars and scratches warrant complete repainting, put the front and rear covers in place, mask all outlets, and spray-paint the entire case.

182. Rustproofing

a. Remove rust from the hinges and catches by cleaning corroded metal with dry-cleaning solvent

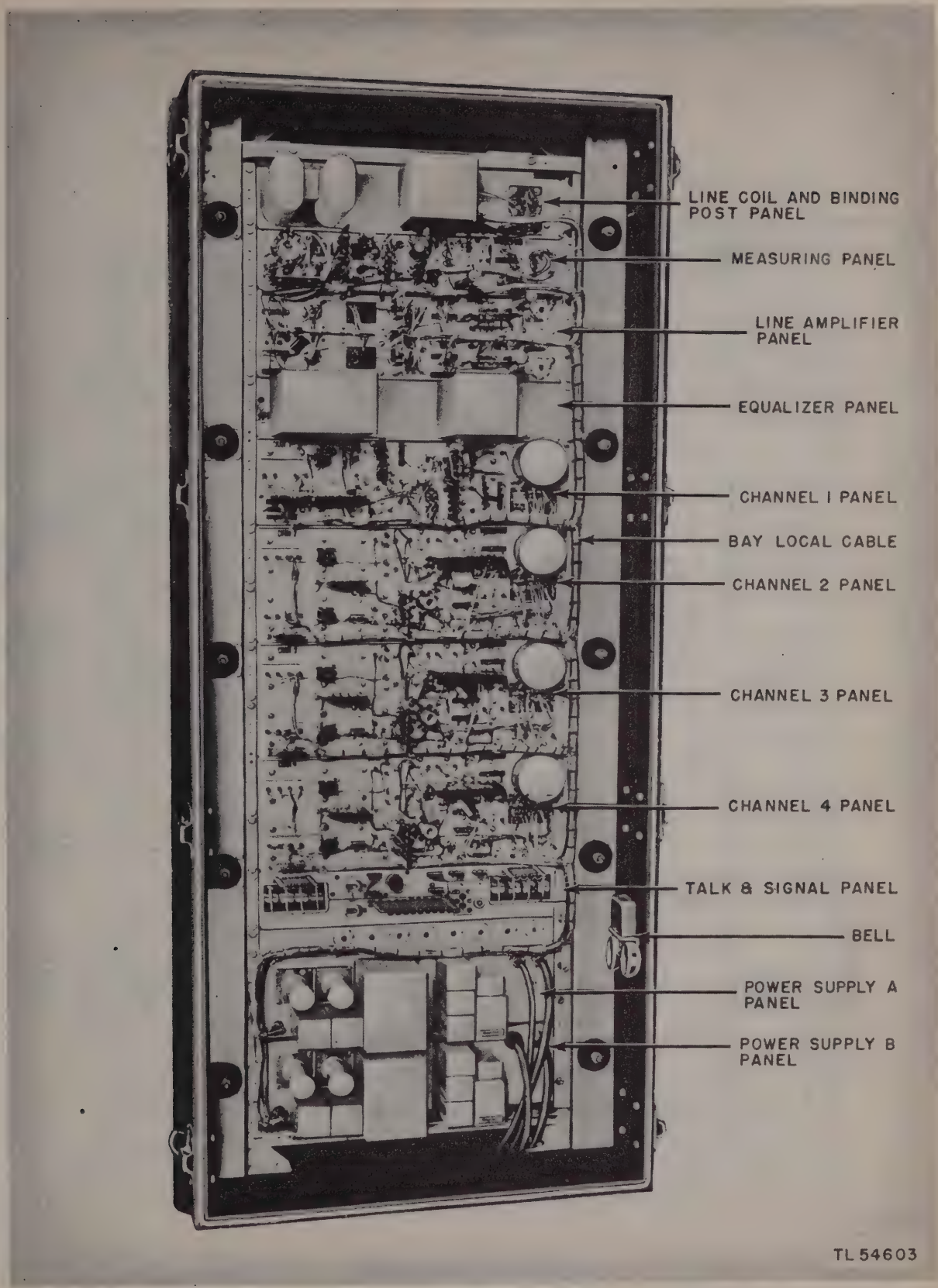

Figure 77. Telephone Terminal CF–1–B, rear view, cover removed.

(SD). In severe cases use dry-cleaning solvent (SD) to soften the rust and #00 or #000 sandpaper to complete the preparation for painting.

b. Touch up the metal hinges and catches with red lead paint. After the red lead paint has dried, repaint and allow the paint to dry thoroughly.

c. If the metal on the panels of the terminal or repeater equipment is spotted with rust, use #00 or #000 sandpaper to remove the rust spots and obtain a smooth, bright finish.

Caution: Do not use steel wool to remove rust from the metal parts of terminal or repeater equipment. Minute particles of steel wool may enter the equipment and cause harmful internal shorting or grounding of circuits.

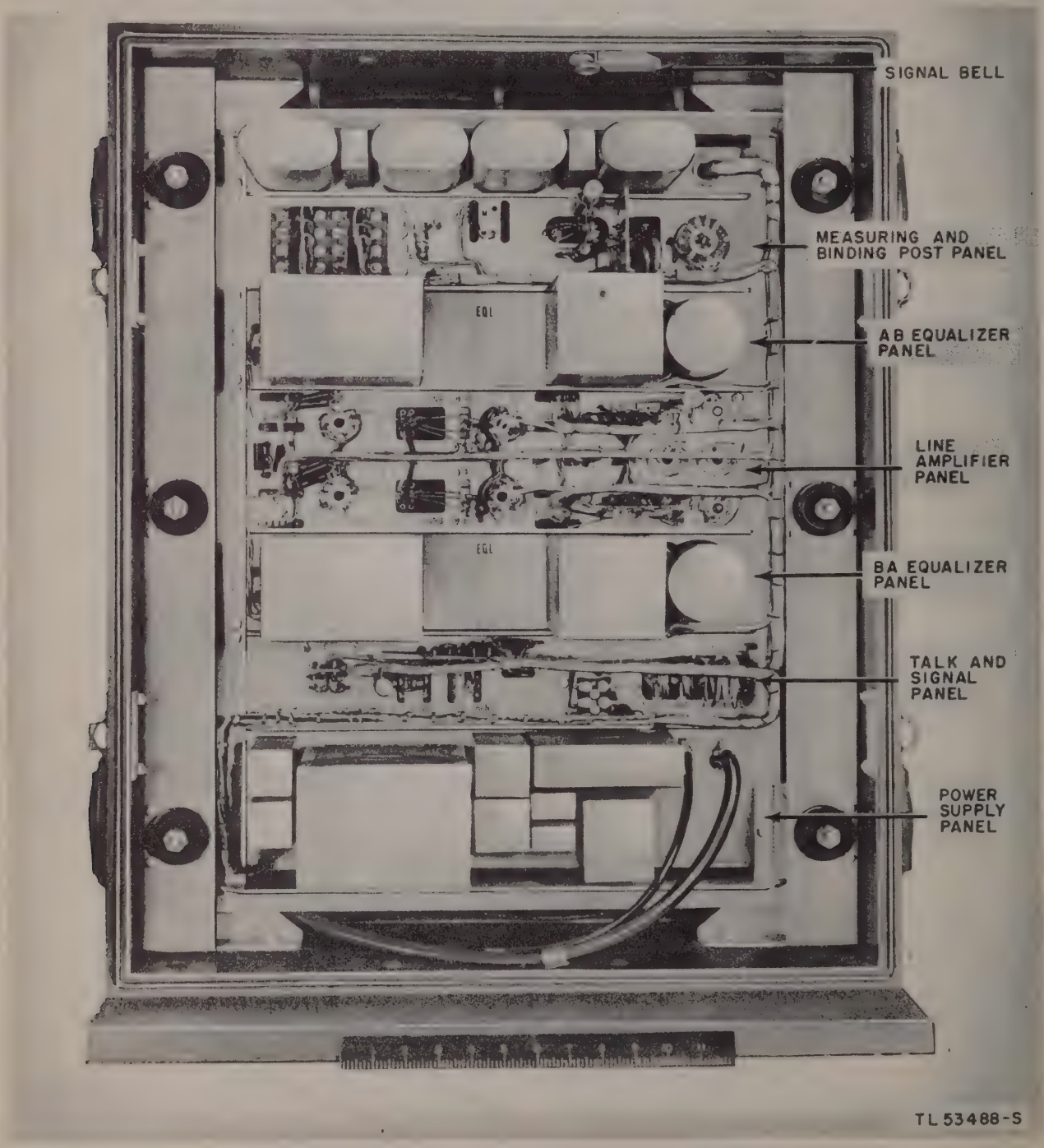

Figure 78. Repeater CF–3–A, rear view, cover removed.

183. Procedure for Returning Equipment to Service

After repairs, replacement of parts, or adjustments which may affect the system line-up, check the entire system before it is returned to service.

a. Place the switches and controls in their proper operating condition.

b. Make the power supply adjustment (par. 61) if the output voltage of the power supply has been affected.

c. Retain any tubes as spares that have been replaced but which pass test requirements. (See par. 76.)

d. Perform the system line-up. (See pars. 87 to 94.)

e. If filters have been replaced, perform the channel frequency net loss test. (See par. 162.)

f. Ring, talk, and listen on the system from its terminations.

g. If the performance of the equipment is satisfactory, return it to service.

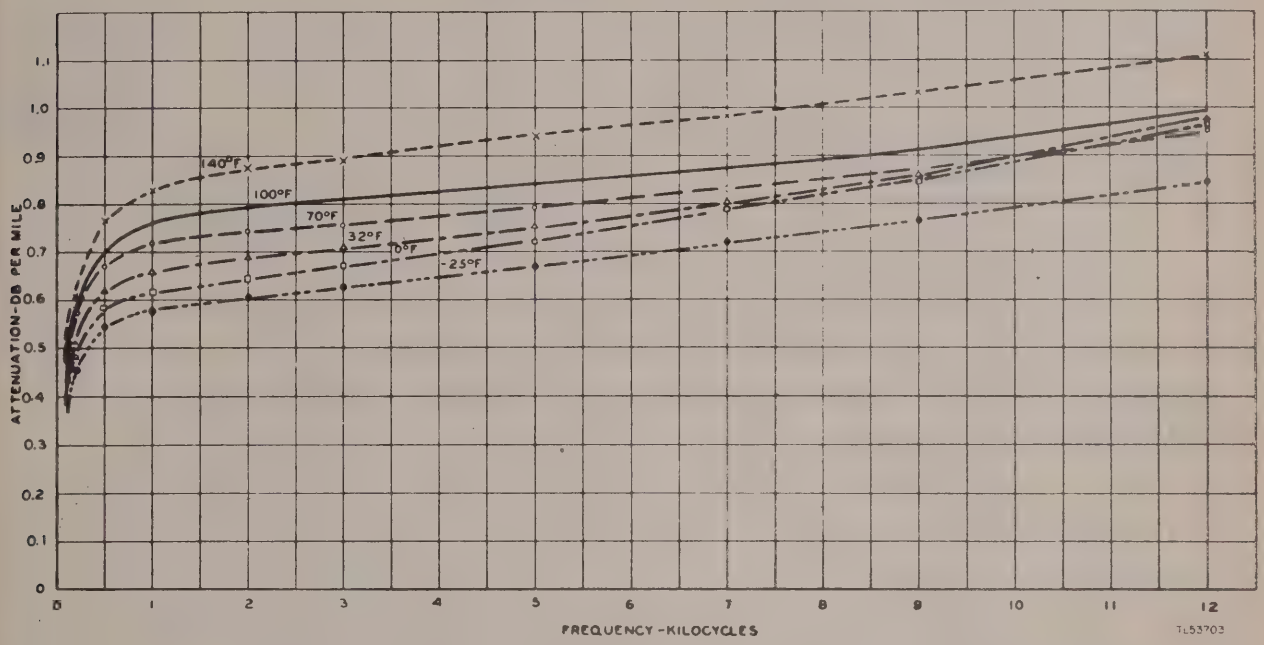

Figure 96. Attenuation of loaded spiral-four cable pairs at various temperatures.

APPENDIX I

LISTS OF COMPONENT PARTS

1. List of Component Parts for Telephone Terminal Set TC–21–(*)

Article	Use	Quantity	
		Per unit	Running spares
Battery BB–55 (6-volt)	Fall-back power	2	
Cable Stub CC–356–(*)	Connects CF–1–(*) to spiral-four cable.	1	1
Case CS–111	Case for two Batteries BB–55.	1	
Chest BC–5	Holds miscellaneous parts.	1	
Clamp TM–106	Connects ground wire to pipe.	2	
Cord CD–711: 50-ft; 2-conductor.	Connects power unit to junction box.	1	1
Cord CO–38: 12-in.; TM–12–A on each end.	Connection between storage batteries.	1	1
Ground Rod MX–148/G	Supplies ground source	2	
Hydrometer HY–2	Testing specific gravity of battery electrolyte.	1	
Junction Box J–85/G	A-c power supply transfer switch.	1	
Junction Box JB–110: with 10 ft. cord.	Multiple power outlets	1	
Power Unit PE–75–(*)	A-c power supply	2	
Rectifier RA–83–A	D-c power for battery charging.	1	
Technical Manual 11–2001	Instruction	1	
Technical Manual 11–369	Instruction	2	
Technical Manual 11–333	Instruction	2	
Telephone EE–8–(*)	For monitoring	1	
Telephone Terminal CF–1–A or CF–1–B.	Principal component	1	
Terminal, battery, positive	Connects battery terminal to battery lead.	2	
Terminal, battery, negative		2	
Test Equipment IE–53	(See par. 15)	1	
Tool Equipment TE–123	(See par. 16)	1	
Wire W–2: 14 ga; bare solid copper.	Ground lead	2 lb.	
Wire W–69–A: 20 ga; weatherproof twisted pair.	Cross-connecting	100 ft.	

NOTES

1. Battery BB–55 is shipped dry-charged. The electrolyte (sp gr 1.280) is shipped in 1-gallon containers usually packed three containers per package. Each Battery BB–55 requires 1.92 gallons of electrolyte.

2. This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

2. List of Component Parts for Repeater Set TC–23–A

Article	Use	Quantity	
		Per unit	Running spares
Battery BB–55 (6-volt)	Fall-back power	2	
Cable Stub CC–356–(*)	Connects CF–3–A to cable	2	
Case CS–111	Case for two batteries BB–55.	1	
Chest BC–5	Holds miscellaneous parts	1	
Clamp TM–106	Connects ground wire to pipe.	2	
Cord CD–711: 50-ft; 2-conductor.	Connects power unit to junction box.	1	1
Cord CO–38: 12-in.; Tm–12–A on each end.	Connection between storage batteries.	1	1
Ground Rod MX–148/G	Supplies ground source	2	
Hydrometer HY–2	Tests specific gravity of electrolyte.	1	
Junction Box JB–110	Multiple power outlets, 10 ft. cord.	1	
Power Unit PE–214	A-c power supply	1	
Rectifier RA–38	D-c power for battery charging.	1	
Repeater CF–3–A	Principal component	1	
Technical Manual 11–369	Instruction	2	
Technical Manual 11–2001	Instruction	1	
Terminal, battery, positive	Connects battery terminal to battery lead	2	
Terminal, battery, negative		2	
Test Equipment IE–53	(See par. 15)	1	
Tool Equipment TE–123	(See par. 16)	1	
Wire W–2: 14 ga; bare solid copper.	Ground lead	2 lb.	

NOTES

1. Battery BB–55 is shipped dry-charged. The electrolyte (sp gr 1.280) is shipped in 1 gallon containers, usually packed three containers per package. Each Battery BB–55 requires 1.92 gallons of electrolyte.

2. This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

APPENDIX II

TABLES

Table LII.—Frequencies of carrier system

Channel No.	Carrier oscillator frequency	Frequency of lower side band (utilized)	Frequency of upper side band (suppressed and not utilized)
1	None	*200–2, 800	None
2	5, 900	3, 100–5, 700	6, 100–8, 700
3	8, 850	6, 050–8, 650	9, 050–11, 650
4	11, 800	9, 000–11, 600	12, 000–14, 600

*Normal band of voice frequencies transmitted over channel 1.

Table LIII.—Temperature-resistance characteristics of spiral-four cable

Temperature (°F.)	Resistance in ohms per looped pair*				
	Per mile of Cable WC-548	Per loading coil D-161642 (2 windings)	1,340-foot Cable Assembly CC-358-E†		Per 100-foot Cable Assembly CC-368-C
			Per assembly	Per 4 assemblies (1 mile)	
−20	57. 3	1. 18	15. 7	62. 6	1. 09
0	60. 2	1. 24	16. 5	66. 0	1. 14
20	63. 4	1. 30	17. 4	69. 5	1. 20
32	65. 1	1. 34	17. 8	71. 4	1. 23
40	66. 4	1. 37	18. 2	72. 9	1. 26
60	69. 5	1. 43	19. 1	76. 1	1. 32
80	72. 6	1. 49	19. 9	79. 6	1. 38
100	75. 7	1. 55	20. 7	83. 0	1. 43
120	78. 7	1. 62	21. 6	86. 4	1. 49
140	81. 8	1. 68	22. 4	89. 7	1. 55

*These resistance values are based upon the resistance for the two conductors of a pair looped at one end and measured at the other end. The values for the loading coil are obtained in the same way.

†While the nominal length of Cable Assembly CC-358-E is 1,320 feet (¼ mile), the average length will be about 1,340 feet. These resistance values include the resistance of the loading coils.

Table LIV.—Power unit data

Power supply	Rated maximum output (watts)	Voltage	Approximate gasoline requirements		
			Tank capacity (qt.)	Consumption per hour (qt.)	Hours for tank capacity
Power Unit PE–75–(*)	2, 500	112–128 a-c	5	3	2
Power Unit PE–214–(*)+	300	112–128 a-c or 224–256 a-c	1⅓	½	3
Power Unit PE–214–(*)±	300	112–128 a-c or 224–256 a-c	5⅓	⅓	16
Power Unit PE–201–(*)**	1,000 or 300	115 a-c or 14.6 d-c	4	2	2

+ One-gallon Auxiliary Tank M–343–A, component of Power Unit PE–214–A, is provided in addition to the 1⅓-quart tank.

± An auxiliary 4-quart Tank M–343–A may be provided to increase the tank capacity of Power Unit PE–214–(*) to 5⅓ quarts. When the power unit is equipped with the auxiliary tank, use the line for 5⅓-quart capacity.

**Power Unit PE–201–(*) was provided with some of the earlier systems. When it is provided, the storage batteries are charged from Power Unit PE–201–(*), and Rectifier RA–83–A is not required.

Table LV.—Power consumption requirements

Quantity	At a terminal	115- or 230-volt, 50- to 60-cycle power (watts)	12-volt storage battery	
			Drain (amp)	Hours of service until recharge is necessary**
1	CF–1–(*)	60	7. 5	20
2	EE–101–A	60	6. 4	†23
1	EE–101–A	30	3. 2	45
1	CF–2–(*)	‡275	(††)	(††)
	Total at terminal	‡395	(†)	
1	CF–(*) ***		13. 9	10
2	EE–101–A ***			
	At a repeater			
1	CF–3–A	30	3. 75	40

**The capacity of storage batteries is affected by temperature. Use 50 to 60 percent of the hours of service when temperature is 0° F, and use 20 to 25 percent when temperature is −30° F.

†Separate 12-volt batteries (two 6-volt Batteries BB–55) are provided for each telephone terminal, for each repeater, and for each of the double-circuit ringers.

‡Maximum power consumption is indicated for Telegraph Terminal CF–2–B. Consumption may be less than that shown, depending upon the telegraph loop conditions. Telegraph Terminal CF–2–A (Carrier) requires 400 to 500 watts or less for both bays, depending upon loop conditions, for high-power consumption.

††No battery provided.

***Use of Telephone Terminal CF–1–(*) and Ringing Equipment EE–101–A on one battery is not recommended except as an emergency measure.

Table LVI.—Maintenance data on battery BB–55

Number of cells	3
Terminal volts	6
Ampere hours (20-hour rate)	150
Amperes (20-hour rate)	7. 5
Terminal volts (discharged)	5. 25
Charging rate (amperes):	
Start	15
Finish	7
Maximum charging volts	7. 5
Over-all dimensions (inches):	
Length	13⅛
Width	7⅛
Height	9⅜
Electrolyte specific gravity:	
Charged	1. 270–1. 300
Discharged	1. 200–1. 240
Weight complete (pounds)	75
Federal specification number	WB 131–B

1. ASF Signal Supply Catalog Pamphlets

The following information was compiled on 5 April 1945. The appropriate sections of the ASF Signal Supply Catalog for Telephone Terminal Set TC–21–(*) and Repeater Set TC–23–A are:

Telephone Terminal Set TC–21.
Sets of Equipment
SIG 6–TE–123 (when published).
Organizational Spare Parts.
SIG 7–TC–21
SIG 7–CF–1
SIG 7–PE–75.
Higher Echelon Spare Parts.
SIG 8–TC–21 Revision
SIG 8–CF–1 Revision
SIG 8–IE–53
SIG 8–PE–75
SIG 8–RA–83
Repeater Set TC–23
Sets of Equipment
SIG 6–TE–123 (when published).
Organizational Spare Parts.
SIG 7–TC–23
SIG 7–CF–3
SIG 7–PE–214
SIG 7–GE–12.
Higher Echelon Spare Parts.
SIG 8–TC–23 Revision
SIG 8–CF–3 Revision
SIG 8–IE–53
SIG 8–PE–214
SIG 8–LE–12
SIG 8–RA–83.

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

2. Maintenance Parts for Telephone Terminal Set TC–21–A and TC–21–B

(See par. 186.)

Ref. symbol	Signal Corps stock No.	Name of part and description
	6Z1906	Clamp TM–106
	3E2038	Cord CO–38.
	3E1711	Cord CD–711.
	3Z3332	Ground Rod.
	5B4428	Ground Rod Clamp.
	3B2202	Hydrometer HY–2.
	6Z1041	Junction Box JB–110.
	3H4575	Power Unit PE–75.
	3H4699–83	Rectifier RA–83–( ).
	4B5008A	Telephone EE–8–( ).
	4B8361A	Telephone Terminal CF–1–A.
	3B4294	Terminal.
	3B4294.1	Terminal.
	3A30	Battery BA–30.
	3A31	Battery BA–31.
	3A42	Battery BA–42.
	2J6SJ7	Tube JAN–6SJ7.
	2J6V6GT	Tube JAN–6V6GT.

3. Maintenance Parts for Repeater Set TC–23–A

(See par. 186.)

Ref. symbol	Signal Corps stock No.	Name of part and description
	3B55	Battery BB–55.
	3B4294	Battery terminal SC–A–1838.
	3B4294.1	Battery terminal SC–A–1838.
	1B146G–12	Cable stub CC–356–G.
	6F705	Chest BC–5.
	6Z1906	Clamp TM–106.
	3E2038	Cord CO–38.
	3E711	Cord CD–711.
	3Z3332	Ground rod.
	5B4428	Ground rod clamp.
	3B2202	Hydrometer HY–2.
	6Z1041	Junction box JB–110.
	3H4600–214	Power unit PE–214–( ).
	3H4699–83	Rectifier RA–83–( ).
	4B3203	Repeater CF–3–( ).
	3Z5370–2	Resistor.
	3Z5410.9	Resistor.
	3F3933–53	Test equipment IE–53–( ).
	3H5443	Tank M–343.
	1A2	Wire W–2.
	2J6SJ7	Tube JAN–6SJ7.
	2J6V6GT	Tube JAN–6V6GT.

APPENDIX III
MAINTENANCE PARTS

1. Maintenance Parts for Telephone Terminals, CF–1–A and CF–1–B

Ref. symbol	Signal Corps stock No.	Name
GRD (PWR A, B)	3Z275	Binding Post.
CH1 T/R, CH2 T/R, CH3 T/R, CH4 T/R, TRSG T/R REC T/R, SX T/R, SH, SIG, (LC); TEL T/R (SIG).	[illegible]	Binding Post.
A (SIG)*	4Z3118	Buzzer.
AC (BAY); AC (PWR A, B).	6Z1727	Cap.
B1, B2 (PWR A, B)	3DB125–1	Capacitor.
D (AMP)	3DA1–96	Capacitor.
E (CH4)	3DA5.980	Capacitor.
E (CH3)	3DA10.690	Capacitor.
E (CH2)	3DA24.170	Capacitor.
B (MEAS)	3DA99.400	Capacitor.
AD (CH1); D, AD (CH2, 3, 4).	3DA3–34	Capacitor.
1B, 2B, (AMP)	3DA100–135	Capacitor.
A (CH1, 2, 3, 4)	3DA195	Capacitor.
E (PWR A, B)	3DB4–52	Capacitor.
C, E (AMP); B, D (LC).	3DA10–158	Capacitor.
A, C (LC); S (SIG)	3DA20–53	Capacitor.
F, G, H, J (PWR A, B).	3DA20–51	Capacitor.
C (MEAS)	3DA44	Capacitor.
K (PWR A, B)*	3DA750	Capacitor.
B (CH1, 2, 3, 4)	3DA400–3	Capacitor.
A1, A2 (PWR A, B)	3DB1E5	Capacitor.
CASE	4Z3202	Carrying Case.
L1, L2 (PWR A, B)	3C1987–66	Coil.
—(PWR A, B)	1B814.31	Cordage.
—(BAY); —(PWR A, B).	1B818.14	Cordage.
AC, AC1 (PWR A, B)	3Z1926	Fuse.
12V BAT +, 12V BAT–(PWR A, B).	3Z2610.10	Fuse.
AC, AC1 (PWR A, B)	3Z3285–2	Fuse Mounting.
—(CH1, 2, 3, 4)	4C5104.79/6	Key Lever Handle.
SEL SW (MEAS), MILES, 1, 2, 4 (EQ), GAIN (CH1, 2, 3, 4).	2Z5848.2	Knob.
CAL (MEAS)	2Z5822–8	Knob.
A (SIG)	6Z6820–3	Lamp.
A (MEAS)	3F3725	Meter.
B1, B2 (PWR A, B)	2Z6722	Capacitor Mounting.
T/R (LC)	4E926	Protector Block.
T/R (LC)	4E927	Protector Block.
V1–V2–V3–V4 (PWR A, B).	3H4956–2	Rectifier.
V5 (PWR A, B) Ø	3H4956–3	Rectifier.
V (CH1); T/R, REC (CH2, 3, 4).	4Z9705	Rectifier.
A, AE (CH1, 2, 3, 4)	3Z6060–30	Resistor.
S, T, U (CH1)	3Z6060–23.1	Resistor.
U, V (MEAS) Ø	3Z6060–23	Resistor.
PB (CH1) Ø	3Z6075–25	Resistor.
S (SIG)	3RC31AE102J	Resistor.
1H, 2H (AMP)	3RC31BE102J	Resistor.
S (MEAS)	3Z6140–2	Resistor.
PC (CH1) Ø	3Z6300–35	Resistor.
AF (CH1, 2, 3, 4)	3RC31AE513J	Resistor.
R (MEAS)	3RC21BE474M	Resistor.
M (CH2, 3, 4)	3RC21BE105M	Resistor.
H (CH1)	3RC41BE183K	Resistor.
F (AMP)	3Z6002–18	Resistor.
M, N (CH1)	3Z6007E5–3	Resistor.
Q (CH2, 3, 4)	3Z6010–63	Resistor.
G (CH1)*	3Z6012–9	Resistor.
G (AMP)	3Z6014–1	Resistor.
PA (CH1) Ø	3Z6014.1	Resistor.
J, K (CH2, 3, 4): A (MEAS) Ø.	3Z6014	Resistor.
AG, AH (CH1, 2, 3, 4).	3Z6015–20	Resistor.
1A, 1B, 2A, 2B (AMP), C, D, E, F, G, H, J, K, L, M (MEAS); MD (CH–1), E, F, (CH–4) Ø.	3Z6030–43	Resistor.
C (AMP)	3Z6040–18	Resistor.
H, N (CH2, 3, 4)	3Z6040–15.1	Resistor.
G (CH3) Ø	3Z6040–15	Resistor.
1E, 2E (AMP) Ø	3Z6610–81	Resistor.
T1 (MEAS) Ø	3Z6080–27	Resistor.
T1 (MEAS)*	3Z5370–2	Resistor.
AC BELL (BAY) Ø	4B3726	Ringer.
12 V +, 12 V — (PWR A, B).	3Z9912A	Terminal.
T (PWR A, B)	2Z9620.1	Transformer.
T1 (PWR A, B) Ø	2Z9620	Transformer.
G (PWR A, B)	3H6694	Vibrator.
	General Hardware	
	6L3606–32.1Z	Nut.
	6L3612–24.1Z	Nut.
	6L6632–18.87	Screw.
	6L7224–10.87	Screw.
	6L9108–6Z	Screw.
	6L52005–6	Washer.
	6L72206–2	Washer.
	6L72212	Washer.
V1 (6S7J) (AMP)	2J6S7J	Tube.
V2 (6V6GT) (AMP)	2J6V6GT	Tube.

NOTES

1. The Ref. symbol column indicates the designation for the part, followed in parentheses ( ), by the panel or position of the equipment in which the part is used.
2. The panels referred to in Ref. symbol column are as follows:
   (AMP) = Line Amplifier Panel
   (BAY) = Telephone Terminal CF–1–(*) complete in case
   (CH 1, 2, 3, 4) = Channels 1, 2, 3 and 4 Panels
   (EQ) = Equalizer Panel
   (LC) = Line Coil and Binding Post Panel
   (MEAS) = Measuring Panel
   (PWR A, B) = Power Supply A and B Panels
3. *In Ref. symbol column after ( ) indicates the part is used only in early model terminals with serial numbers 1 to 516, inclusive. Early model power supply panels are those supplied with terminals with serial Nos. below 381.
4. Ø In Ref. symbol column after ( ) indicates the part is used only in late model terminals with serial Nos. 517 and above. Late model power supply panels are those supplied with terminals with serial No. 381 and above. Where an item is used in both the early and late models but the total quantity per assembly has changed, the greater quantity is shown.

2. Maintenance Parts for Repeater CF-3-A

Ref. symbol	Signal Corps stock No.	Name
AC (PWR)	6Z1727	Cap.
B1, B2 (PWR)	3DB125–1	Capacitor.
D (AMP AB); D (AMP BA).	3DA1–96	Capacitor.
F, G, H, J (PWR)	3DA20–53	Capacitor.
A, D, E, H (LC & M)	3DA20–51	Capacitor.
B, C, F, G (LC & M)	3DA10–158	Capacitor.
K (PWR)*	3DA750	Capacitor.
B (AMP AB); B (AMP BA).	3DA100–135	Capacitor.
A (AMP BA); A (AMP AB).	3DB2–7	Capacitor.
AB, BA (LC & M)	3DB1.136C	Capacitor.
—(BAY)	3E333	Cord CC–333.
—(PWR)	1B814.31	Cordage.
—(PWR)	1B818.14	Cordage.
AC, AC1 (PWR)	3Z1926	Fuse.
12 V BAT +, 12 V BAT − (PWR).	3Z2610.17	Fuse.
A (LC & M)	3F3725	Meter.
T/R (LC & M)	4E926	Protector block.
T/R (LC & M)	4E927	Protector block.
E (AMP AB)	3Z6610–81	Resistor.
C, D (T & S)	3Z6030–36	Resistor.
F (AMP AB); F (AMP BA).	3Z6002–18	Resistor.
E (LC & M) Ø	3Z6015–20	Resistor.
D (LC & M) Ø	3Z6047–11	Resistor.
E (T & S)	3Z6060–36	Resistor.
A (LC & M)*	3Z6074C3–1	Resistor.
S (LC & M)	3Z6140–2	Resistor.
H (AMP AB); H (AMP BA).	3RC31AE102J	Resistor.
AB, BA (LC & M)	3RC21BE202J	Resistor.
D (AMP AB); D (AMP BA).	3RC31BE302J	Resistor.
A, B (T & S)	3RC31AE513J	Resistor.
12 V +, 12 V − (PWR).	3Z9912A	Terminal.
G (PWR)	3H6694	Vibrator.
	General hardware	
	6L3603–32.1Z	Nut.
	6L6632–18.87	Screw.
	6L52005–6	Washer.
V2 (6V6GT) (AMP)	2J6V6GT	Tube.
V1 (6SJ7) (AMP)	2J6SJ7	Tube.

NOTES

1. The letters and numbers in the Ref. symbol column refer to the designations of the apparatus items. The abbreviations in parentheses in this column refer to equipments as follows:

Amplifier	(AMP)
Amplifier AB	(AMP AB)
Amplifier BA	(AMP BA)
Equalizer (EQ)	(EQ)
Equalizer AB	(EQ AB)
Equalizer BA	(EQ BA)
Line Coil and Measuring	(LC & M)
Power	(PWR)
Talk and Signal	(T & S)

2. Ø Denotes items used only in later models CF–3–(A) with serial No. 1100 and above.

3. *Denotes items used in early models CF–3–(A), only with serial Nos. 1 to 1100, inclusive. Early model power supply panels are those supplied with repeaters with serial numbers below 723.

APPENDIX IV

REFERENCES

Note.—For availability of items listed, check FM 21–6, and ASF Catalog SIG 2. Also see FM 21–6 for applicable Technical Bulletins, Supply Bulletins, Modification Work Orders, and Changes.

1. Army Regulations

AR 380–5 ..... Restricted Documents.

2. Parts Lists

*SIG 1 ..... Introduction to ASF Signal Supply Catalog.
SIG 3 ..... List of Items for Troop Issue.
SIG 4–1 ..... Allowances of Expendable Supplies.
SIG 4–2 ..... Allowances of Expendable Supplies for Schools, Training Centers, and Boards.
SIG 5 ..... Stock List of All Items.
*SIG 6–TE–123 ..... Sets of Equipment.
SIG 7–AN/TCC–2 ..... Organizational Spare Parts.
SIG 7–CF–1 ..... Organizational Spare Parts.
SIG 7–CF–3 ..... Organizational Spare Parts.
SIG 7–GE–12 ..... Organizational Spare Parts.
SIG 7–PE–75 ..... Organizational Spare Parts.
SIG 7–PE–201 ..... Organizational Spare Parts.
SIG 7–PE–214 ..... Organizational Spare Parts.
SIG 7–TC–21 ..... Organizational Spare Parts.
SIG 7–TC–23 ..... Organizational Spare Parts.
SIG 8–AN/TCC–2 ..... Higher Echelon Spare Parts.
SIG 8–CF–1 ..... Higher Echelon Spare Parts.
SIG 8–CF–3 ..... Higher Echelon Spare Parts.
SIG 8–EE–8 ..... Higher Echelon Spare Parts.
SIG 8–GE–12 ..... Higher Echelon Spare Parts.
SIG 8–IE–53 ..... Higher Echelon Spare Parts.
SIG 8–PE–75 ..... Higher Echelon Spare Parts.
SIG 8–PE–201 ..... Higher Echelon Spare Parts.
SIG 8–PE–214 ..... Higher Echelon Spare Parts.
SIG 8–RA–83 ..... Higher Echelon Spare Parts.
SIG 8–TC–21 ..... Higher Echelon Spare Parts.
SIG 8–TC–23 ..... Higher Echelon Spare Parts.
SB 11–6 ..... Dry Battery Supply Data.
SB 11–8 ..... Chests for Running Spares.
SB 11–10 ..... Signal Corps Kit and Materials for Moisture-resistant and Fungi-resistant Treatment.

3. Technical Manuals on Accessory Equipment and Test Equipment

TM 11–333 ..... Telephones EE–8, EE–8–A, and EE–8–B.
TM 11–342 ..... Ringing Equipments EE–100–T1 EE–100–A, and EE–101–A (Voice Frequency).
TM 11–355 ..... Telegraph Terminal CF–2–A (Carrier).
TM 11–355B ..... Telegraph Terminal CF–2–B (Carrier).
TM 11–368 ..... Tactical Open Wire Pole Line Construction.
TM 11–369 ..... Spiral-Four Cable.
TM 11–371 ..... Cable Assemblies C–345 (5-pair), CC–355–A (10-pair), and Associated Equipment.
TM 11–900 ..... Power Units PE–75–C through –W and PE–75–AA through –AE.
TM 11–914 ..... Power Unit PE–201–A.
TM 11–914C ..... Power Unit PE–201–C.
TM 11–945 ..... Power Unit PE–214–B.
TM 11–963 ..... Rectifier RA–83–A.
TM 11–2001 ..... Complete 100-Mile Spiral-Four Carrier System.
TM 11–2003 ..... Carrier Hybrid CF–7.
TM 11–2009 ..... Telegraph Terminal CF–6 (Carrier).
TM 11–2014 ..... Telephone Unit EE–105.
TM 11–2017 ..... Test Set TS–26/TSM.
TM 11–2046 ..... 67B and 67B (SPL) Test Set.
TM 11–2057 ..... Test Set TS–27/TSM.
TM 11–2601 ..... Radio Set AN/TRC–1, Radio Terminal Set AN/TRC–3, Radio Relay Set AN/TRC–4, and Amplifier Equipment AN/TRA–1.
TM 11–2613 ..... Voltohmmeter I–166.
TM 11–2627 ..... Tube Tester I–177.

4. Painting, Preserving, and Lubrication

TB SIG 13 ..... Moistureproofing and Fungiproofing Signal Corps Equipment.

5. Shipping Instructions

U. S. Army spec
No. 100–14A ..... Army-Navy General Specifications for Packaging and Packing for Oversea Equipment.

6. Decontamination

TM 3–220 ..... Decontamination.

7. Demolition

FM 5–25 ..... Explosives and Demolitions.

* When available.

8. Camouflage

FM 5–20 Camouflage, Basic Principles.

9. Other Technical Publications

FM 21–8 Military Training Aids.
FM 21–40 Defense Against Chemical Attacks.
FM 24–20 Field Wire Systems.
TB 9–850–4 Use of Solvent, Dry Cleaning.
TB 9–850–15 Use of Dry Cleaning Solvents.
TB SIG 25 Preventive Maintenance of Power Cords.
TB SIG 29 Impedance Unbalance Tests for Coils C–161 and C–285.
TB SIG 44 Maintenance of Spiral four and Tactical Open wire Carrier Equipment.
TB SIG 50 Maintaining Telephone Communication under Gas Conditions.
TB SIG 64 Expedient Means of Determining Frequency of Supply Using Line Unit BE–77–A and BE–77–B.
TB SIG 66 Winter Maintenance of Signal Equipment.
TB SIG 67 Laying Field Cable Under Water.
TB SIG 69 Lubrication of Ground Signal Equipment.
TB SIG 72 Tropical Maintenance of Ground Signal Equipment.
TB SIG 75 Desert Maintenance of Ground Signal Equipment.
TB SIG 78 Instructions for Initial Line-up and Check of Levels in Standard Multichannel Radio Communication System.
TB SIG 79 Instructions for Replacing Broken Glass in Meters with Plastic Material.
TB SIG 101 Long-Range Tactical Wire W–143.
TB SIG 121 Tying and Use of Weave Tie for Field Wire and Cables.
TB SIG 122 Adapter M–418, Part of Test Set I–56–A, –B, –C, –D, –E, –H, –J, and –L and Tube Tester I–177.
TB SIG 123 Preventive Maintenance Practices for Ground Signal Equipment.
TB SIG 128 Emergency Use of Telephone Repeater EE–99–A as a Substitute for Repeater CF–3–A (Carrier), and as a Four-wire Repeater on Cable Facilities.
TM 1–455 Electrical Fundamentals.
TM 11–430 Batteries for Signal Communication Except those Pertaining to Aircraft.
TM 11–455 Radio Fundamentals.
TM 11–475 Principles of Long Distance Telephone and Telegraph Transmission.
TM 11–486 Electrical Communication Systems Engineering.
TM 11–487 Electrical Communication Systems Equipment.
TM 11–499 Radio Propagation Handbook.
TM 11–755 Grounds, Grounding Procedure, and Protective Devices for Wire Communication Equipment.
TM 37–250 Basic Maintenance Manual.

10. Forms

Army Air Forces—Form 54. Unsatisfactory Report.
WD AGO Form 468 Unsatisfactory Equipment Report.

11. List of Abbreviations

A adjust.
ac alternating current.
adj adjust.
amp ampere.
amp amplifier.
arm armature.
BAT battery.
C clean.
CAL calibrate.
cap capacitor.
cc cubic centimeter.
CH channel.
CHAN channel.
cps cycles per second.
cu cubic.
~ cycle.
°F degrees Fahrenheit
db decibel.
dc direct current.
EQL equalizer.
equip equipment.
EXT extension.
F feel.
fig figure.
freq frequency.
ft foot.
ga gauge.
GRD ground.
hp horsepower.
I inspect.
imp impedance.
IMPED impedance.
in inch.
kc kilocycle.
L lubricate.
LEV level.
med medium.
MEAS measuring.
mf microfarad.
MFP moistureproofed and fungiproofed.
mh millihenry.
misc miscellaneous.
MON monitor.
mmf micromicrofarad.
net network.
number.
No number.
Ω ohm.
ω ohm.
opr operate.
OSC oscillator.
par paragraph.

PWR SUP	power supply.
REC	receiving.
rep	repeating.
rpm	revolutions per minute.
req	required.
2d	second.
SC	Signal Corps.
SH	shield.
SIG	signal.
sp gr	specific gravity.
spec	specification.
SWBD	switchboard.
subpar	subparagraph.
SX	simplex.
T	tighten.
TEL	telephone.
teleg	telegraph.
term	terminal.
TLG	telegraph.
trans	transformer.
TRSG	transmitting.
v	volt.
vf	voice frequency.
w	watt.
W	wire.
WD AGO	War Department, Adjutant General's Office.

12. Glossary

AUTOMATIC FALL-BACK. The automatic transfer of the power supply from a commercial source or from a power unit 60-cycle source to power supplied from a frequency generator (vibrator) operating from a 12-volt storage battery to furnish 60-cycle, 110-volt supply.

BATTERY. This term is sometimes used loosely to designate any source of direct current.

CARRIER CIRCUIT. The part of a complete telephone or telegraph circuit which uses carrier current for the transmission of signals. The line connecting two Telephone Terminals CF–1–(*) is a carrier circuit.

CARRIER CURRENT. An alternating current usually used with a modulator to shift the frequency of the normal telephone or telegraph signals into a different portion of the frequency spectrum. The amount of the shift is determined by the frequency of the carrier current and of the initial message current.

CARRIER TELEPHONE. A method of utilizing carrier frequencies which makes possible the transmission of two or more telephone messages over the same pair of wires without interference.

CARRIER TELEGRAPH. A method of utilizing carrier frequencies which makes possible the transmission of two or more telegraph messages (series of pulses) over the same circuit without interference.

CHANNEL. The path of a single frequency, or a band of frequencies, allotted for a specified telephone or telegraph circuit, usually over a carrier system. A channel may be *one-way* providing transmission in only one direction, or *two-way* providing transmission in both directions.

CROSS. An electrical connection between a conductor or conductors of one pair and a conductor or conductors of another pair. Usually refers to a fault on a line.

DECIBEL. Two amounts of power differing according to the relation $db = 10 \log_{10} (P_1/P_2)$.

DBM. Decibels above or below 1 milliwatt; positive sign indicates above, negative sign below.

ECHO. A reflected current or a current returning through a singing path. This current is received some time after the original current is received by the talker or listener. It is heard as an echo or affects transmission as an echo.

EQUALIZATION. The adjustment of the gain-frequency characteristic of an amplifier to compensate for the loss-frequency characteristics of the line so that all frequencies in the band of frequencies under consideration have the same loss or gain at the output of the amplifier.

GROUND. An electrical connection made to earth so that electrical energy can flow to or through the earth's surface. Usually refers to the protective connections used to drain off unwanted energy, such as energy produced from lightning, or to the return path for ungrounded circuits. Also, a fault when wires are broken and lying on the ground.

KEY. A kind of switch operated by a knob, push-button, or lever.

LINE AMPLIFIER. An amplifier common to all channels in one direction used to compensate for the line losses. Normally associated directly with the line.

MODULATION, DEMODULATION. The process of shifting a band of frequencies from one position in the frequency spectrum to another position by the action of a carrier current. The amount of shift is determined by the carrier frequency.

OPEN. The open-circuited condition of a circuit which breaks the conductor continuity. Usually refers to a fault in the line.

PHANTOM. A circuit derived by using repeating coils that provide a third circuit from two pairs of conductors. Each pair forms a conductor (the two wires in parallel) for the phantom circuit.

PHYSICAL. The metallic circuit formed by a pair of conductors in contrast to a circuit derived as a phantom circuit or carrier channel.

Power Supply. The source of a-c or d-c power and its conversion to proper voltage values for use in the associated component of equipment.

Rectifier. A unit of equipment that transforms alternating current to direct current. This may apply to either power or communication energies.

Repeater Section. The line section between terminals when no repeaters are used, between a terminal and a repeater, or between repeaters. Usually denotes the part of the line included between the equipment of adjacent stations in an over-all system.

Signaling. Usually used to denote the circuit or equipment provided for a *calling in* alarm (signaling) as distinguished from the communication paths or equipment.

Short, Short Circuit. An electrical connection between the conductors of a pair. Usually refers to a fault on a line or to a temporary connection made during tests. A short is called *high resistance* if it has more than 10,000 ohms resistivity, or *low resistance* if the resistivity is less than 10,000 ohms.

Simplex. A d-c circuit derived from a pair of wires. Usually used to provide a grounded d-c telegraph circuit on a communication pair without interference to it. The circuit is formed by using the midpoint tap of a line coil at either end of the circuit.

Singing. The condition where sustained oscillation occurs around a closed path through parts of the circuit, including amplifiers or repeaters and, generally, hybrid coils. A continuous tone may usually be heard, and telegraph or other signals passing over the circuit may be adversely affected. Although singing may occur at some frequency outside the band of frequencies used, it still may cause the channel or system to be affected or to fail because of amplifier overloading or other effects.

Thermistor. A resistor with a negative temperature coefficient whose resistance decreases rapidly when the temperature increases.

Varistor. A metallic type of rectifier, often of the copper-oxide type.

Voice-Frequency. Applied to the band of frequencies generated by the human voice. For a spiral-four carrier system the band is designated as from about 200 to 2,800 cycles.

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Unpacking, uncrating, and checking	58	40
Weights and volumes packed for shipment	58	40
Telephone Unit EE–105	1*j*, 11	4, 11
Test equipment	153	110
Test Equipment IE–53	10	11
Test Set TS–190/U	10	11
Test Set I–171	76	57
Testing arrangements at:		
Repeater CF–3–A	156	112
Telephone Terminal CF–1–A	154	110
Telephone Terminal CF–1–B	155	112
Tool Equipment TE–123	9	11
Tools and repair equipment, use of	171	131
Terminal blocks, preventive maintenance of	123	83
Terminal, missing, operation with	110	75
Termination:		
Four-wire	1*c*, 66*b*	1, 47
Two-wire	1*c*, 65, 66*a*	1, 46, 47
Terminal receiving amplifier, adjustment of output of	90	62
Transformers and filter chokes, preventive maintenance of	126	84
Transmission measurements	162	117
Transmission measuring equipment	161	117
Transmitting circuit, check of	98, 100	65, 67
Transmitting terminal, measurement of output of	88	61
Trouble location	134, 154–162	91, 110
Tube Tester I–177	76	57
Unsatisfactory equipment reports	137	91
Use of diagrams and charts	159	116
Vacuum tube and power supply voltages, measurement of	160	116
Vacuum tubes:		
Periodic check of	76	57
Preventive maintenance of	120	81
Types used in Telephone Terminal CF–1–(*)	147	102
Wire, open, operation over	42	32
Wire W–143:		
Emergency operation without equalizer	41	32
Use of in spiral-four systems	40	30
Wiring diagrams	136	91

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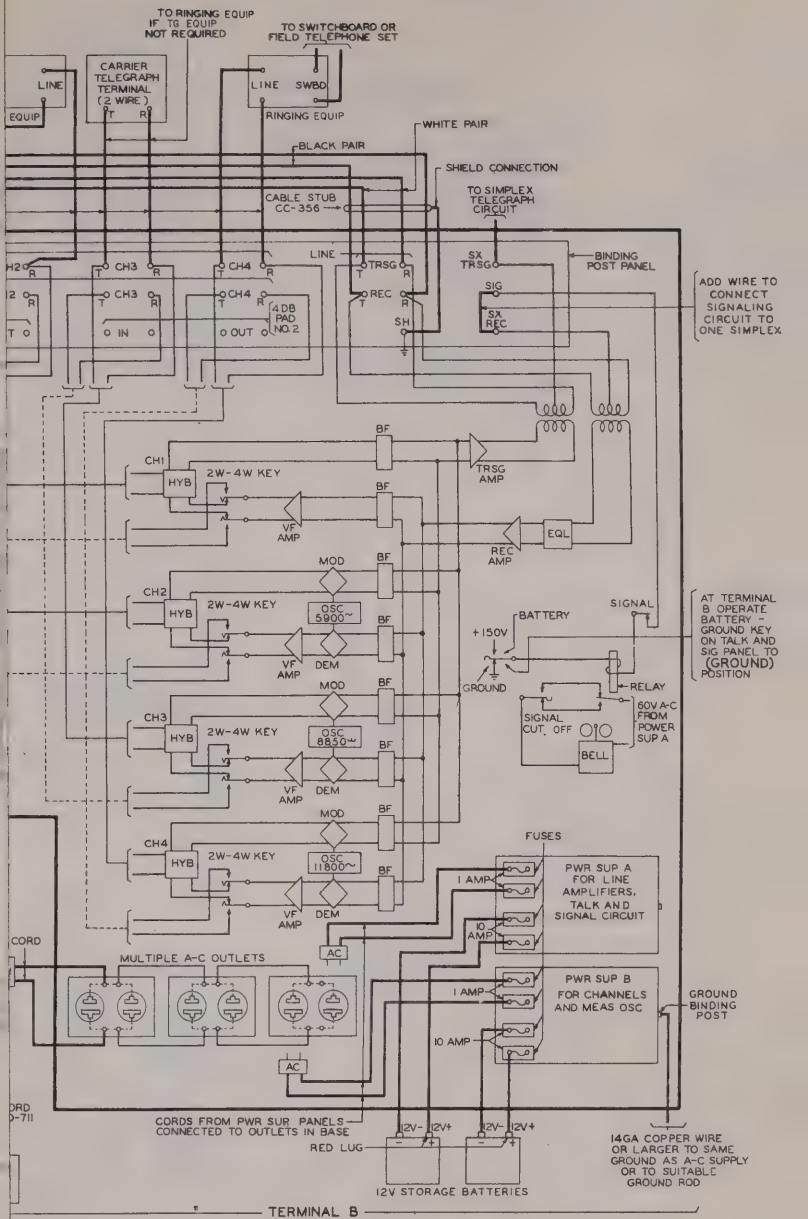
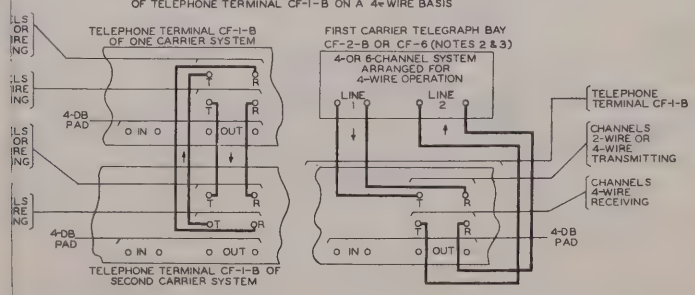


TERMINAL B (INSET)

CONNECTIONS FOR TERMINATING A CHANNEL OF TELEPHONE TERMINAL CF-1-B ON A 4-WIRE BASIS



OR TERMINAL B (INSET)
NNECT A CHANNEL OF CF-1-B TO A CHANNEL
-1-A OR OTHER TELEPHONE EQUIPMENT ON
BASIS SEE TECHNICAL MANUAL.
OR 6-CHANNEL TELEGRAPH SYSTEM CONNECT
OWN. FOR 8-CHANNEL SYSTEM CONNECT 4-DB
ETWEEN LINE 1 BINDING POSTS ON TELEGRAPH
ND 4-WIRE TRANSMITTING BINDING POSTS ON
B BAY. FOR 10-OR 12-CHANNEL TELEGRAPH

SYSTEM REPLACE 4-DB PAD BY 8-DB PAD TO SECURE 8 DB PAD CONNECT 4-DB PADS NO. 1 AND NO. 2 IN TANDEM.

3. FOR CONNECTIONS TO CF-2-A OR OTHER TYPES OF VF TELEGRAPH EQUIPMENT SEE TECHNICAL MANUAL.

4 OPERATE CHANNEL TERMINATION KEY ON TALK AND SIG PANEL TO 4 WIRE.

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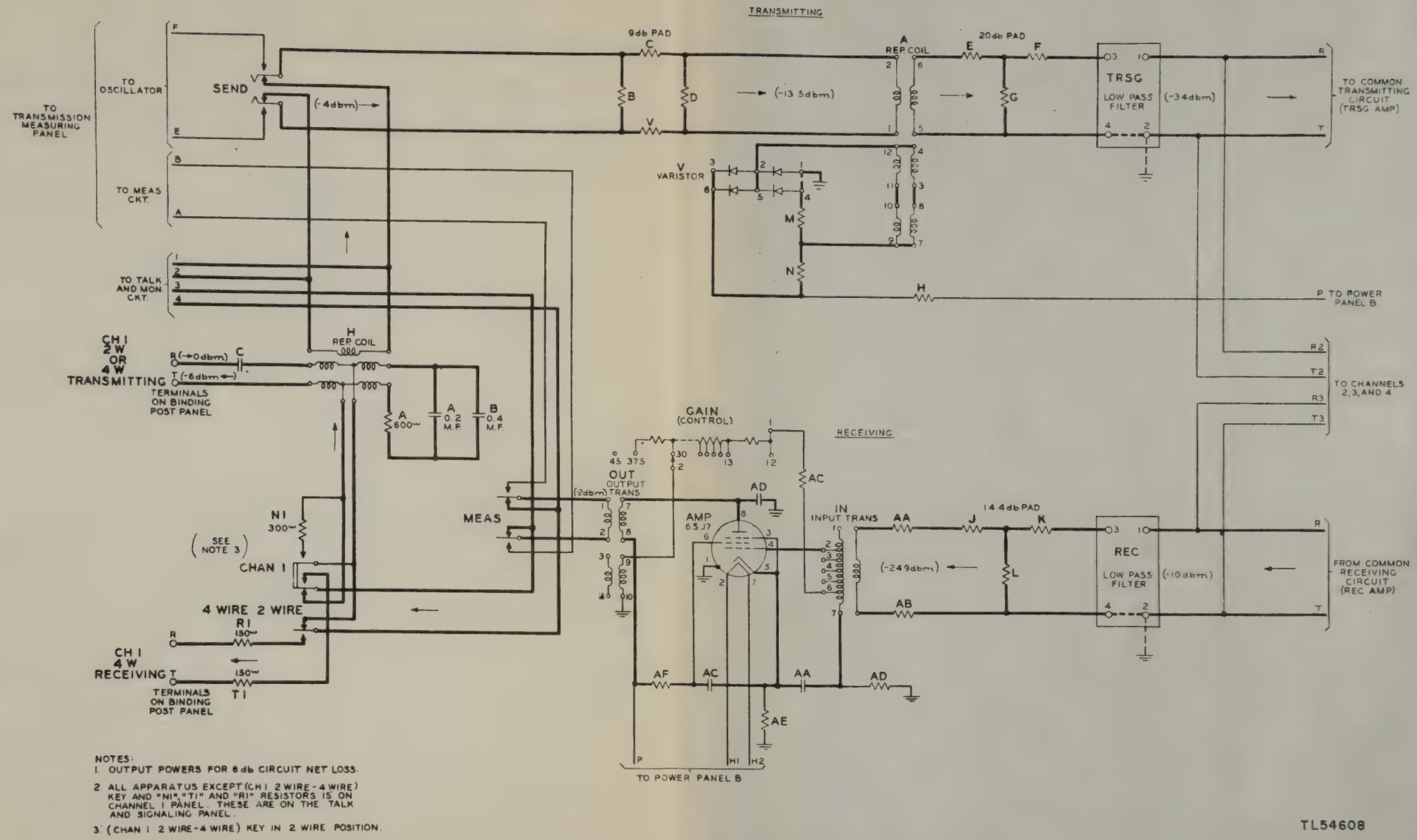
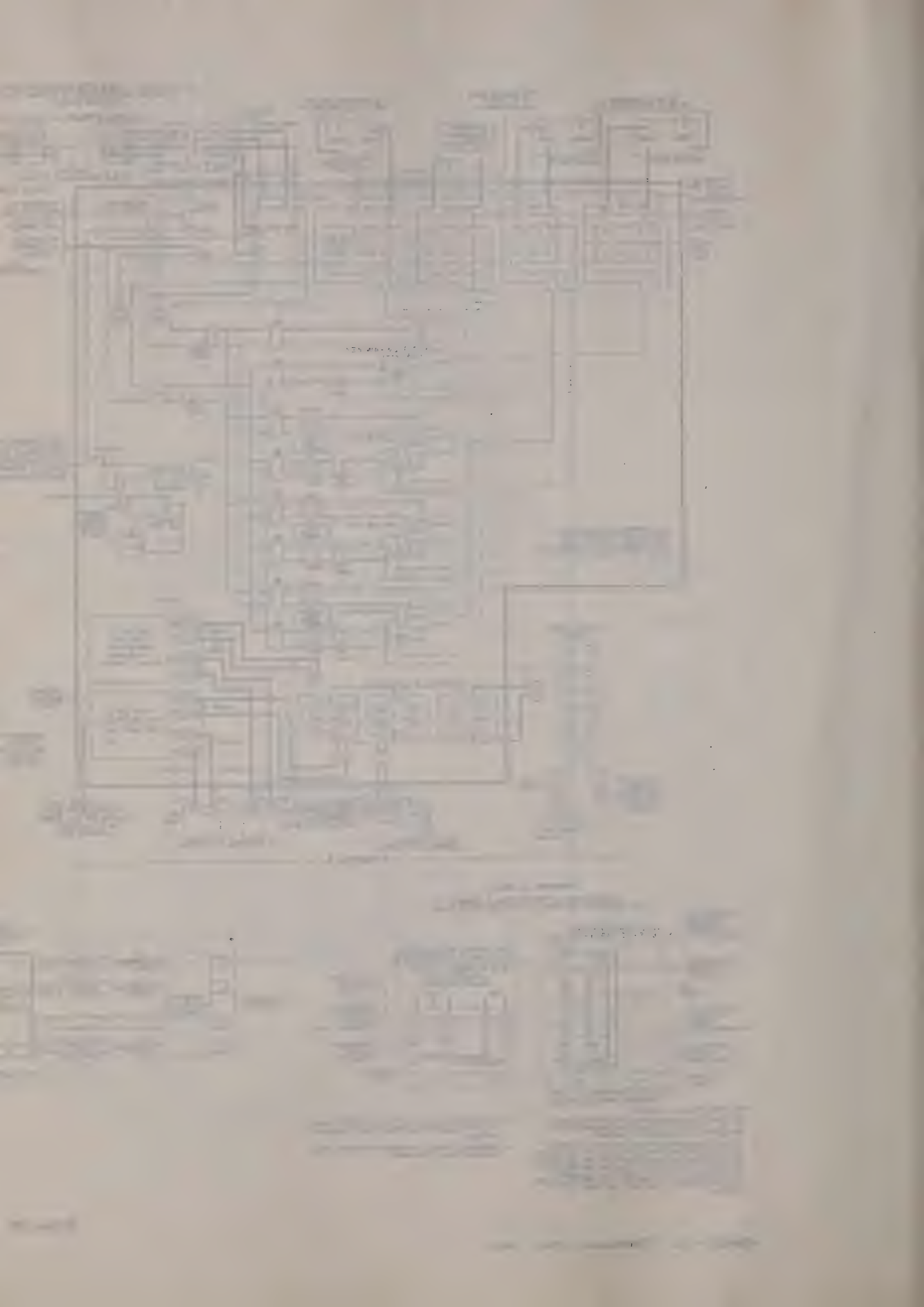
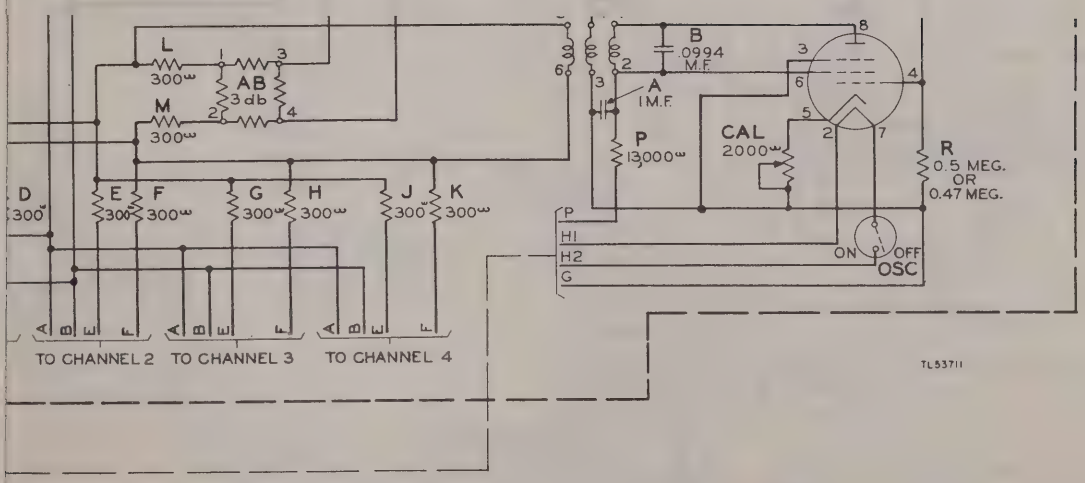


Figure 58. Telephone Terminal CF–1–B, channel 1 transmitting and receiving circuits, schematic diagram.




L
300ω
AB
3 db
M
300ω
B
.0994
M.F.
A
1M.F.
P
13,000ω
CAL
2000ω
R
0.5 MEG.
OR
0.47 MEG.
D
300ω
E
300ω
F
300ω
G
300ω
H
300ω
J
300ω
K
300ω
P
H1
H2
G
ON
OFF
OSC
TO CHANNEL 2
TO CHANNEL 3
TO CHANNEL 4
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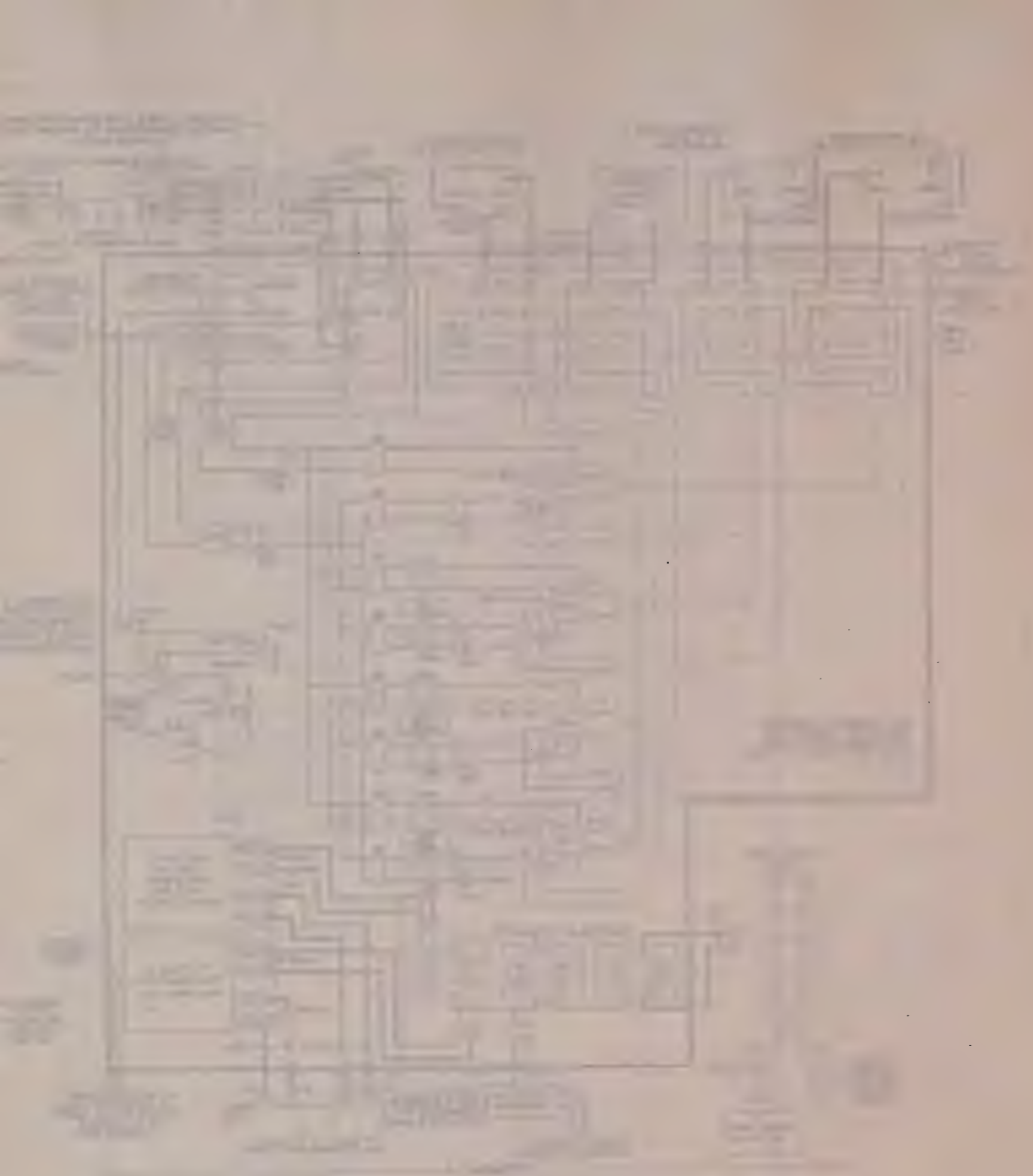
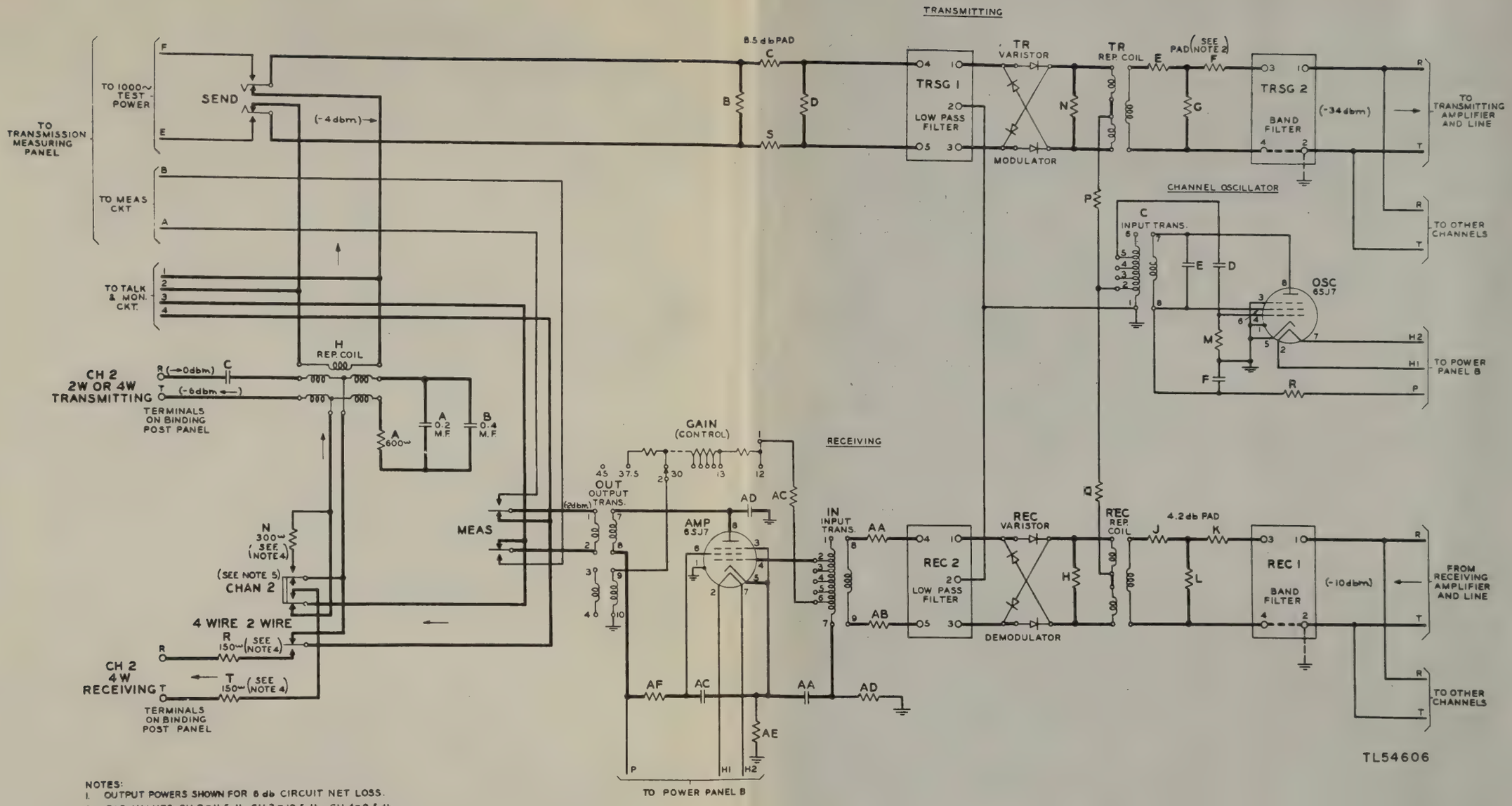
ic diagram

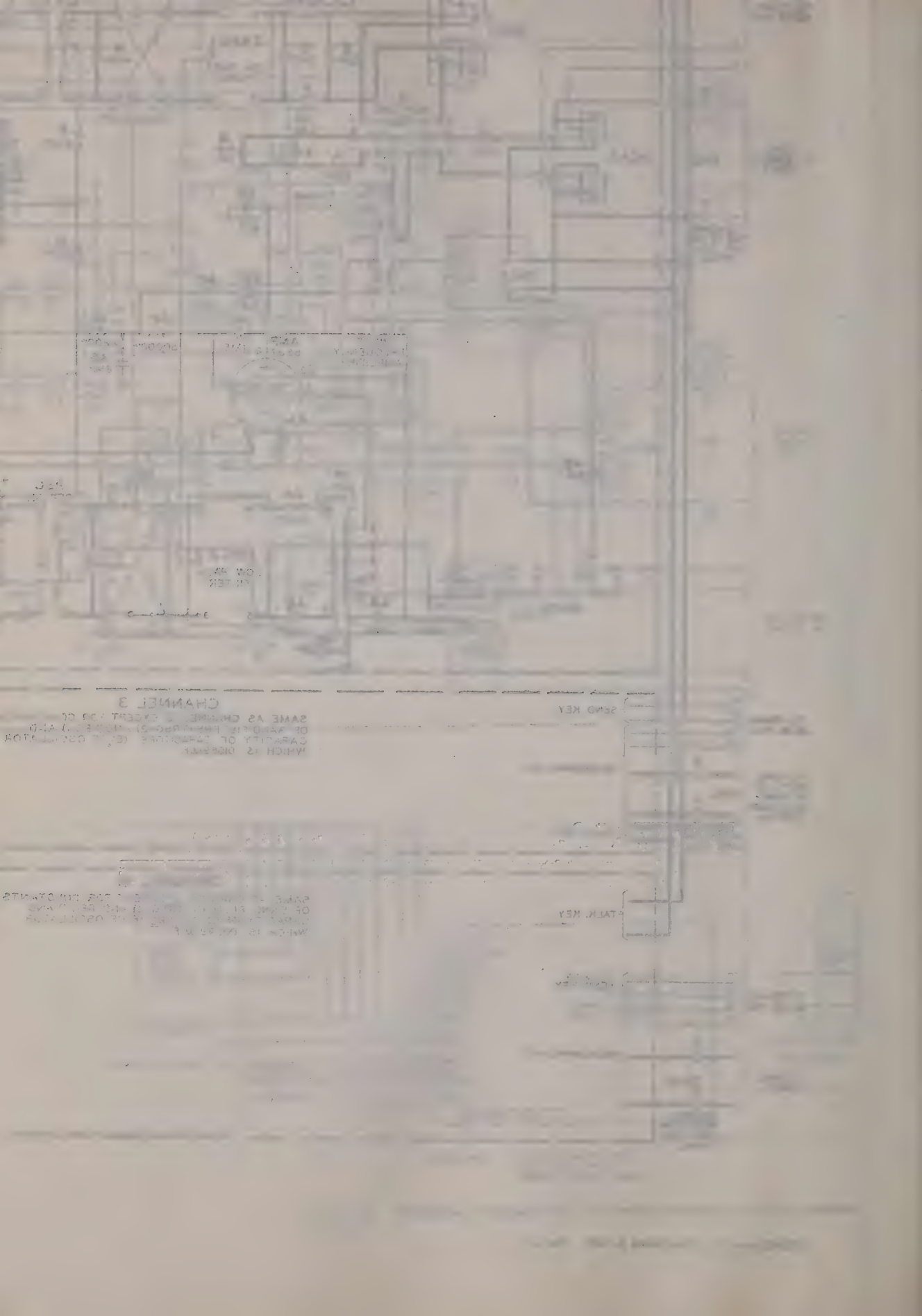




NOTES:

1. OUTPUT POWERS SHOWN FOR 6 db CIRCUIT NET LOSS.
2. PAD VALUES, CH 2 = 11.5 db, CH 3 = 10.5 db, CH 4 = 9.5 db.
3. ALL APPARATUS EXCEPT (CH 2 WIRE-4 WIRE) KEY AND "N", "T", "R" RESISTORS IS ON CHANNEL PANEL. THESE ARE ON THE TALK AND SIGNALING PANEL.
4. THE "N", "T" AND "R" RESISTORS HAVE A NUMBER FOLLOWING THE LETTER CORRESPONDING TO THE CHANNEL IN WHICH THE RESISTOR IS USED, AS ON CHANNEL 2 THE "N" RESISTOR IS DESIGNATED "N2."
5. (CHAN 2 2 WIRE-4 WIRE) KEY IN 2 WIRE POSITION.

Figure 60. Telephone Terminal CF–1–B, channel 2, 3, or 4 transmitting and receiving circuits, schematic diagram.



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SEE NOTE 8
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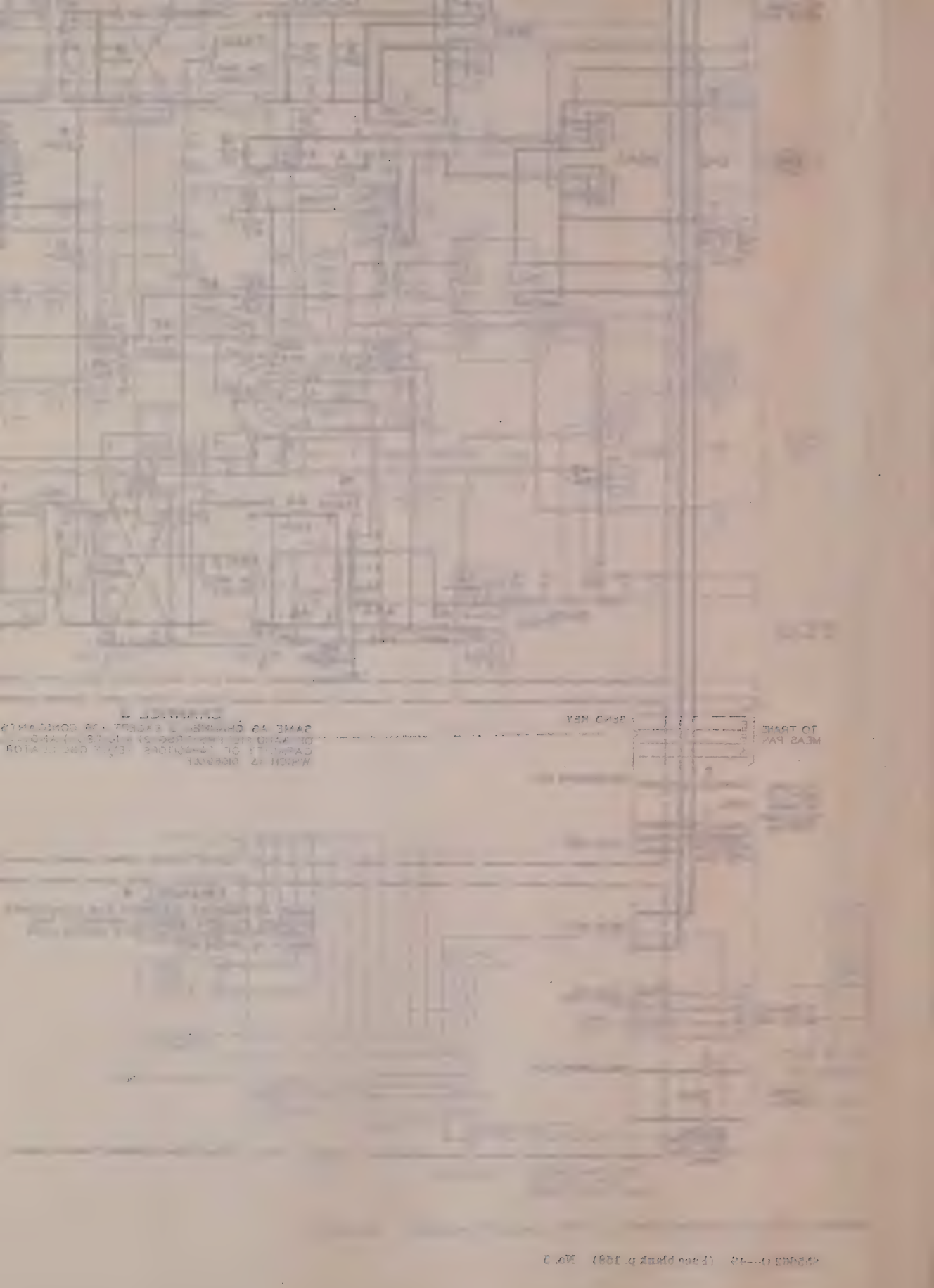


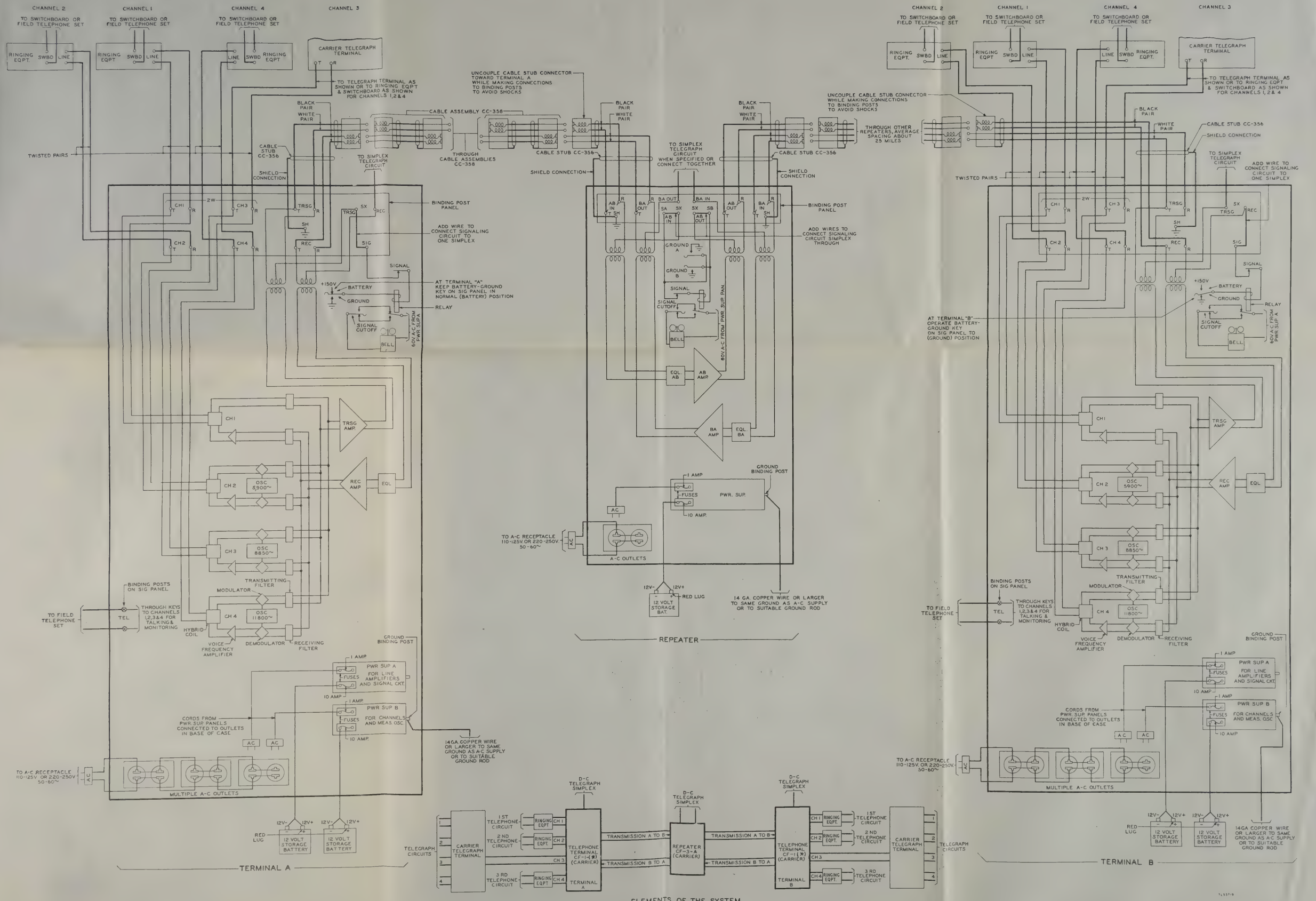
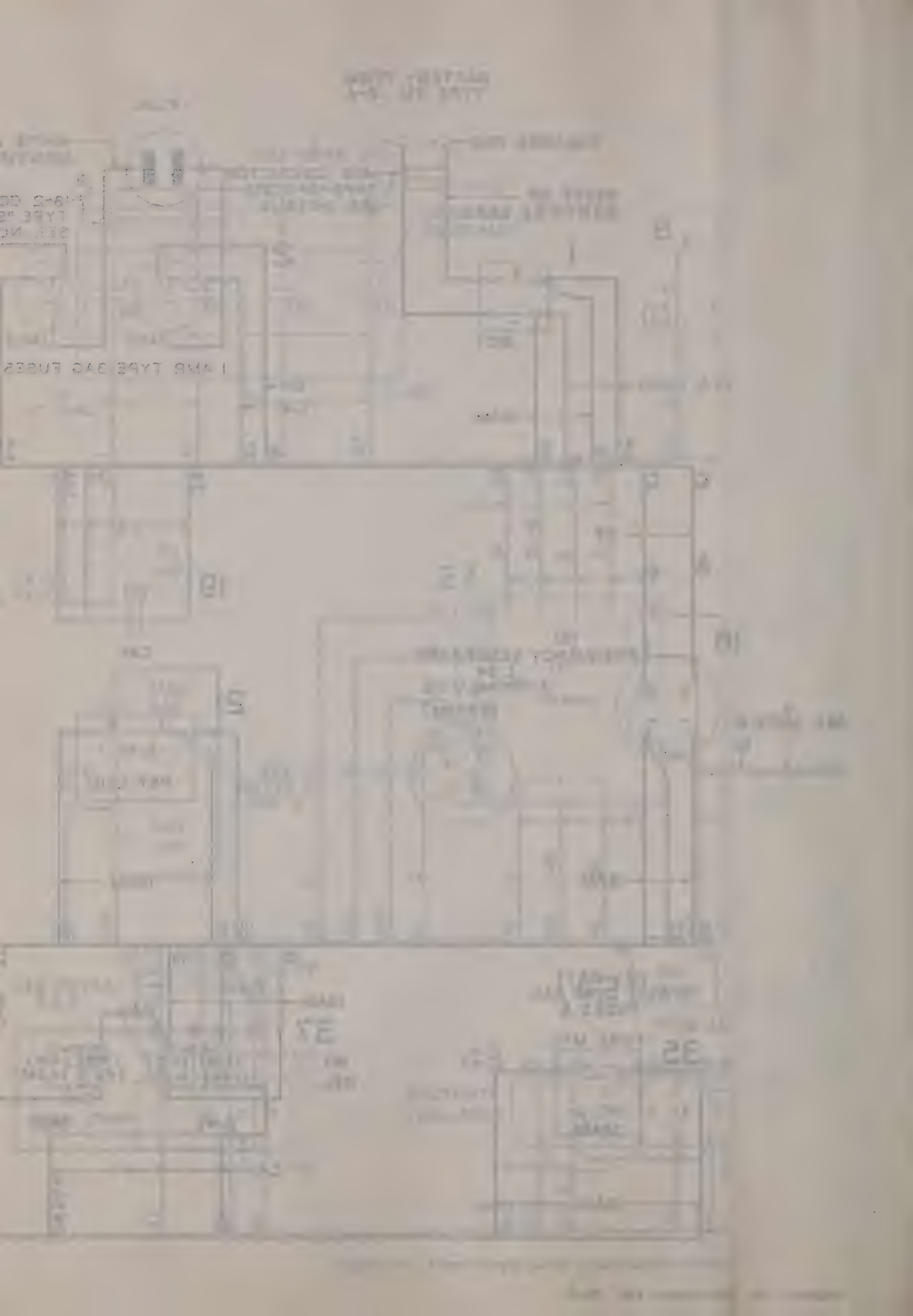
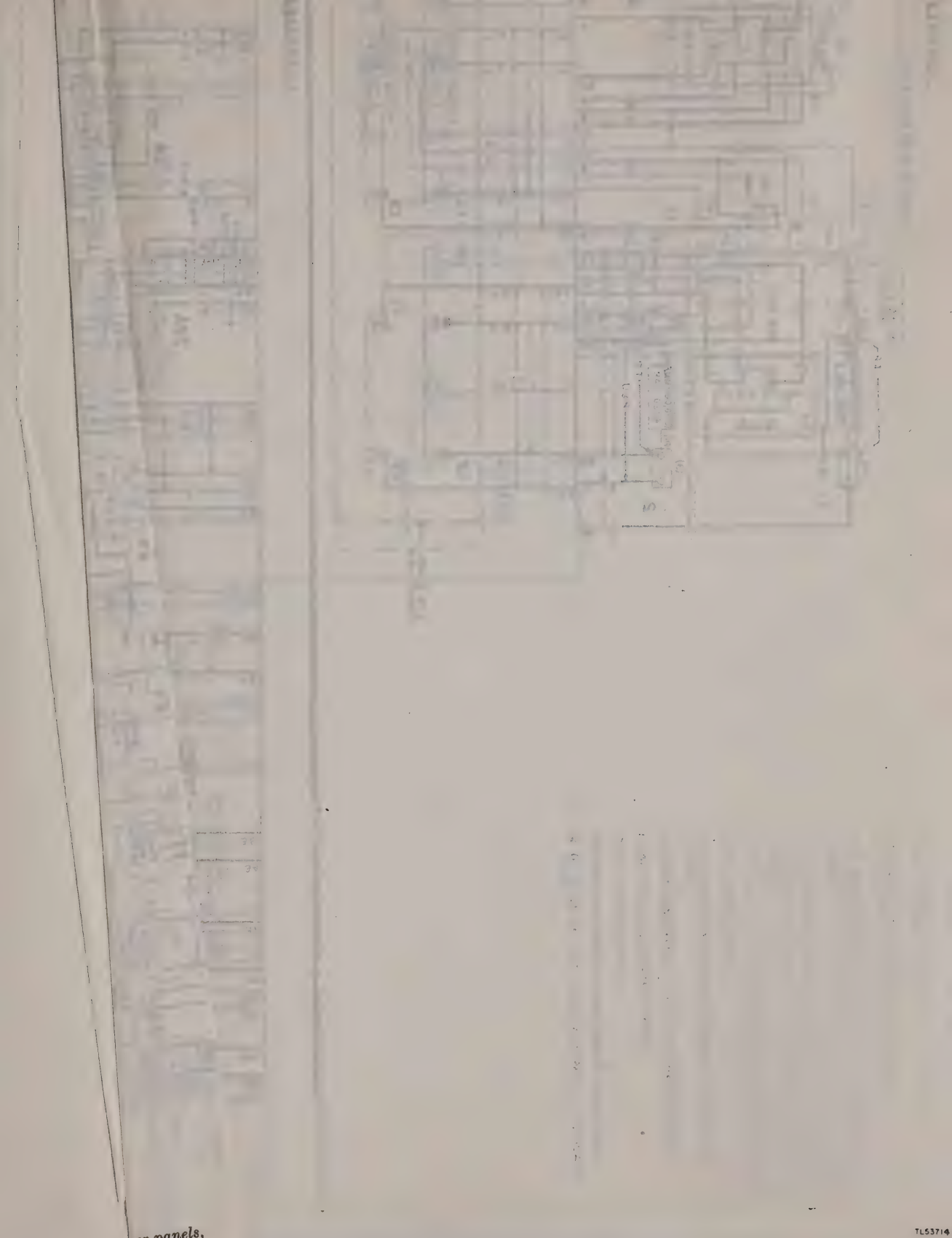


Figure 79. Schematic diagram of system using Telephone Terminals CF-1-A.





zer panels,

8

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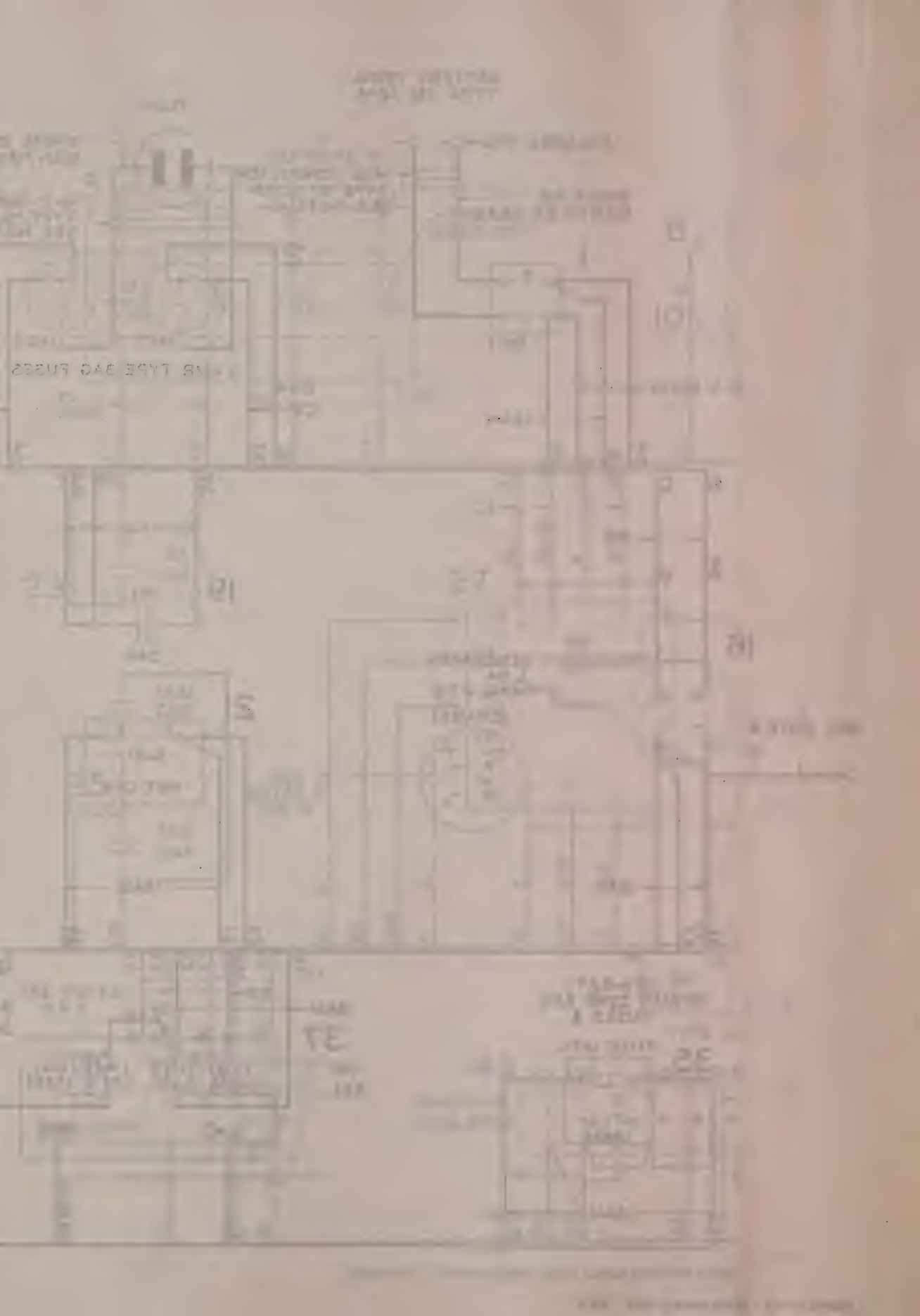
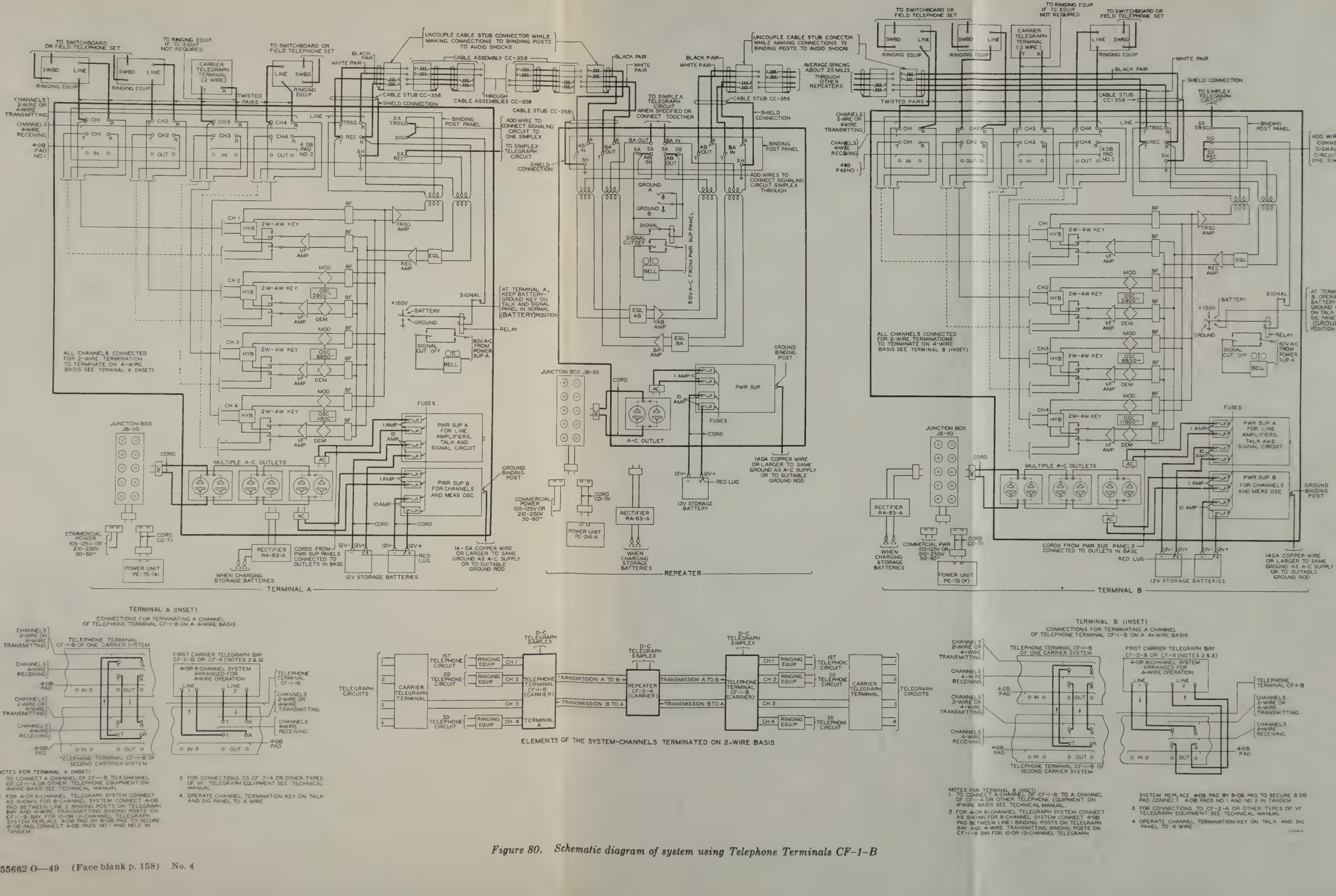




TERMINAL A (INSET)

CONNECTIONS FOR TERMINATING A CHANNEL OF TELEPHONE TERMINAL CF-1-B ON A 4-WIRE BASIS

NOTES FOR TERMINAL A (INSET)

1. TO CONNECT A CHANNEL OF CF-1-B TO A CHANNEL OF CF-1-A OR OTHER TELEPHONE EQUIPMENT ON 4-WIRE BASIS SEE TECHNICAL MANUAL.
2. FOR 4-OR 6-CHANNEL TELEGRAPH SYSTEM CONNECT AS SHOWN FOR 8-CHANNEL SYSTEM CONNECT 4-DB PAD BETWEEN LINE 2 BINDING POSTS ON TELEGRAPH BAY AND 4-WIRE TRANSMITTING BINDING POSTS ON CF-1-B BAY. FOR 10-OR 12-CHANNEL TELEGRAPH SYSTEM REPLACE 4-DB PAD BY 8-DB PAD TO SECURE 8-DB PAD, CONNECT 4-DB PADS NO 1 AND NO 2 IN TANDEM
3. FOR CONNECTIONS TO CF 2-A OR OTHER TYPES OF VF TELEGRAPH EQUIPMENT SEE TECHNICAL MANUAL.
4. OPERATE CHANNEL TERMINATION KEY ON TALK AND SIG PANEL TO 4 WIRE

ELEMENTS OF THE SYSTEM-CHANNELS TERMINATED ON 2-WIRE BASIS

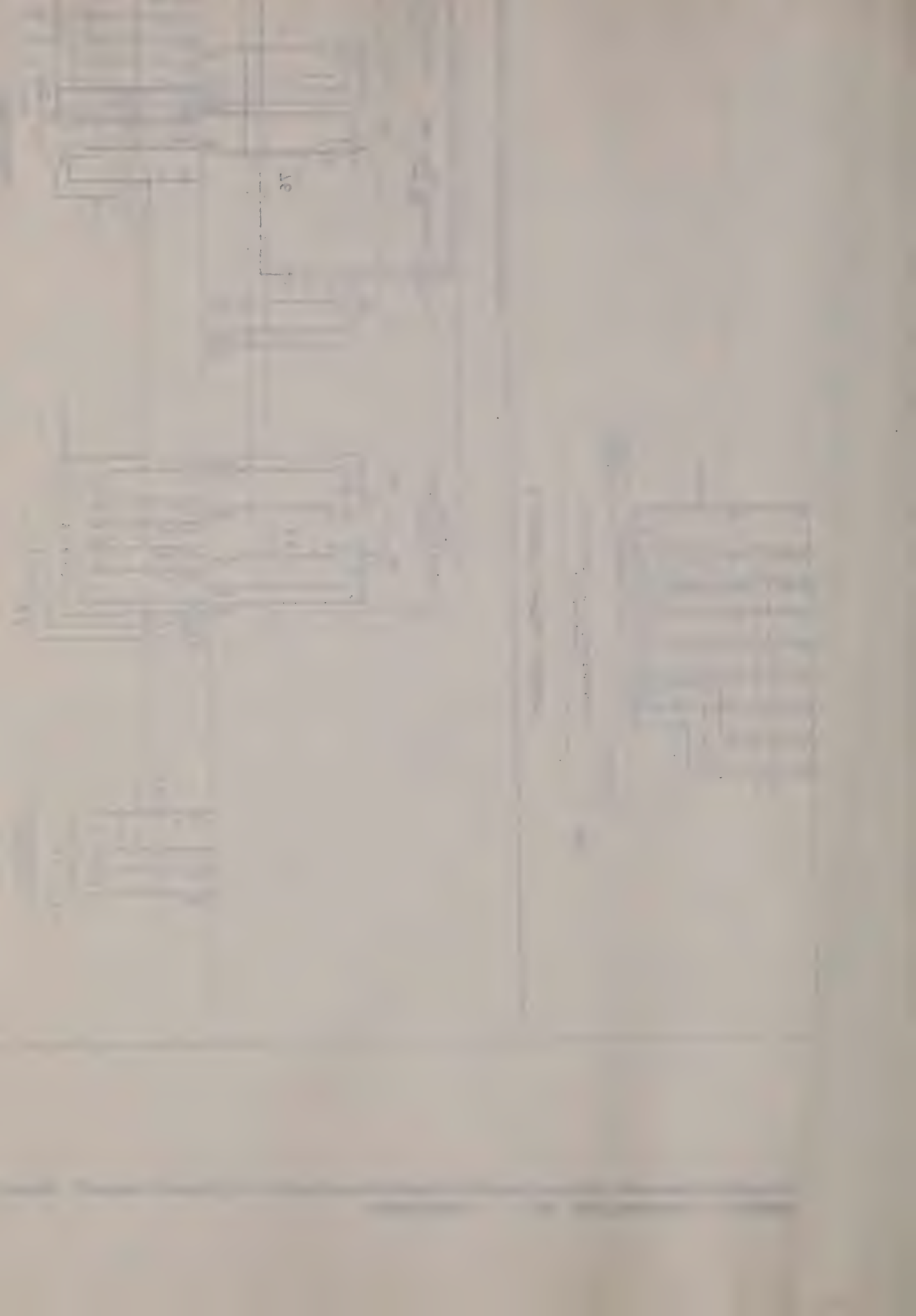
TERMINAL B (INSET)

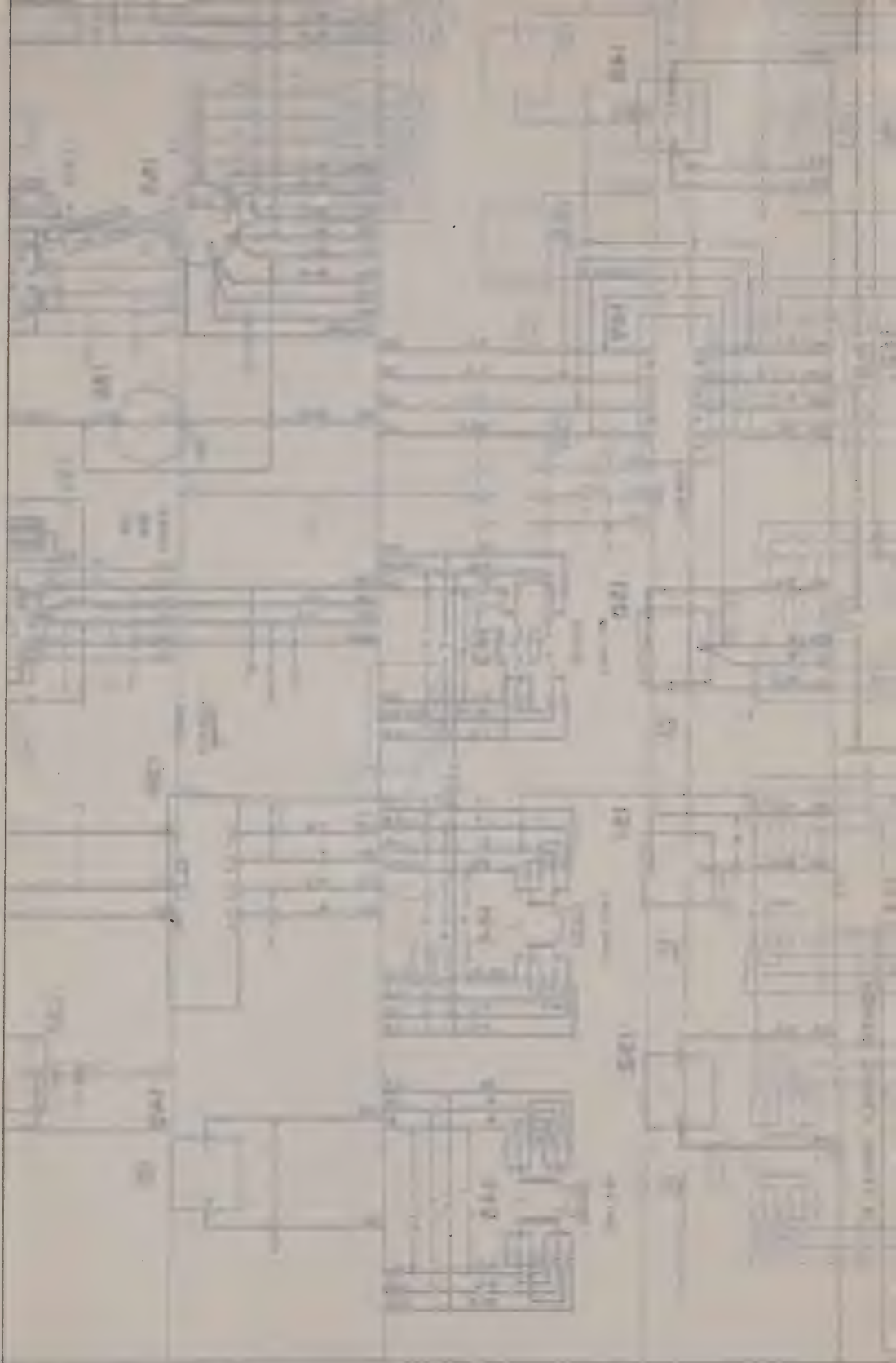
CONNECTIONS FOR TERMINATING A CHANNEL OF TELEPHONE TERMINAL CF-1-B ON A 4-WIRE BASIS

NOTES FOR TERMINAL B (INSET)

1. TO CONNECT A CHANNEL OF CF-1-B TO A CHANNEL OF CF-1-A OR OTHER TELEPHONE EQUIPMENT ON 4-WIRE BASIS SEE TECHNICAL MANUAL.
2. FOR 4-OR 6-CHANNEL TELEGRAPH SYSTEM CONNECT AS SHOWN FOR 8-CHANNEL SYSTEM CONNECT 4-DB PAD BETWEEN LINE 1 BINDING POSTS ON TELEGRAPH BAY AND 4-WIRE TRANSMITTING BINDING POSTS ON CF-1-B BAY FOR 10-OR 12-CHANNEL TELEGRAPH SYSTEM REPLACE 4-DB PAD BY 8-DB PAD TO SECURE 8 DB PAD CONNECT 4-DB PADS NO 1 AND NO 2 IN TANDEM
3. FOR CONNECTIONS TO CF-2-A OR OTHER TYPES OF VF TELEGRAPH EQUIPMENT SEE TECHNICAL MANUAL.
4. OPERATE CHANNEL TERMINATION KEY ON TALK AND SIG PANEL TO 4 WIRE.

Figure 80. Schematic diagram of system using Telephone Terminals CF–1–B





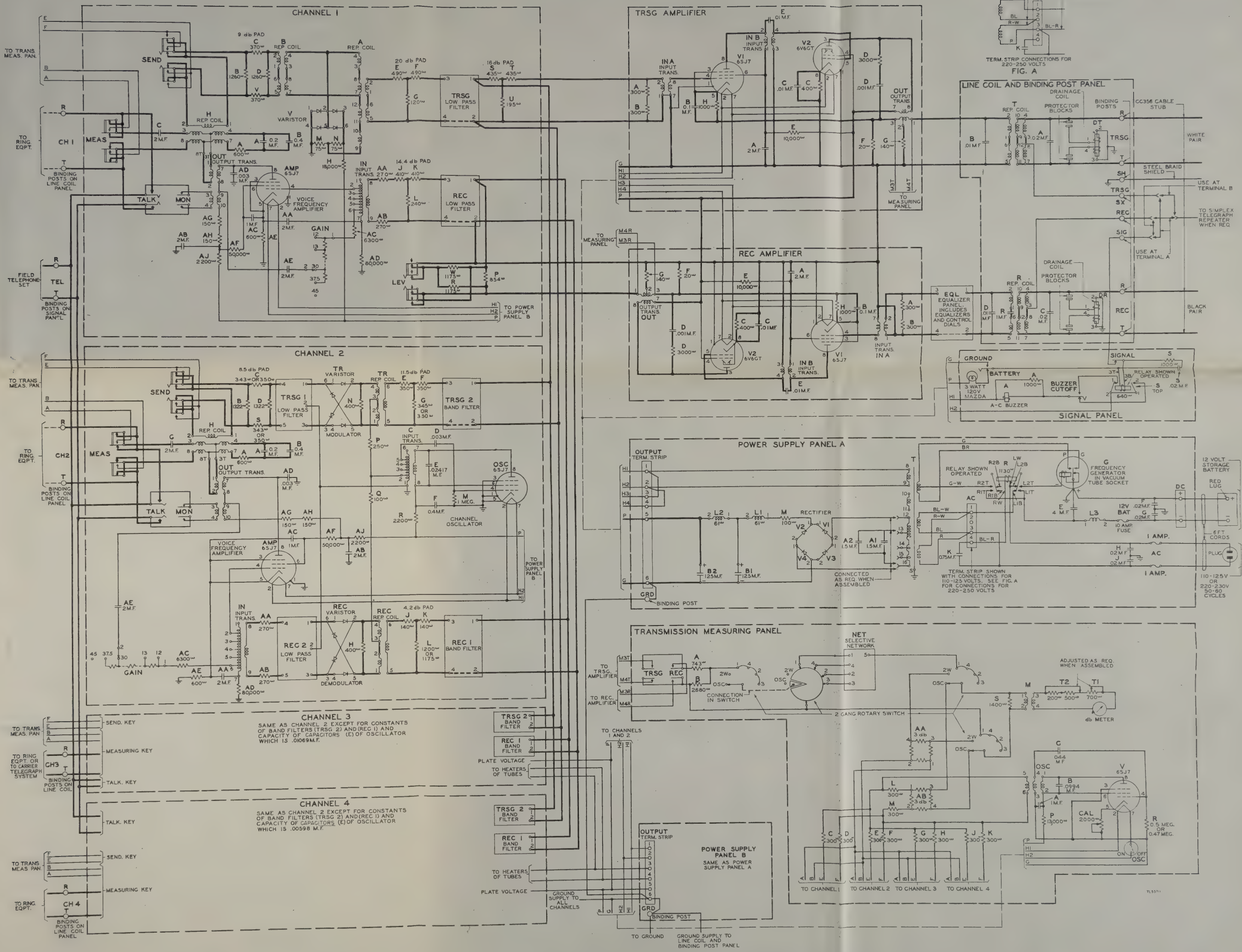
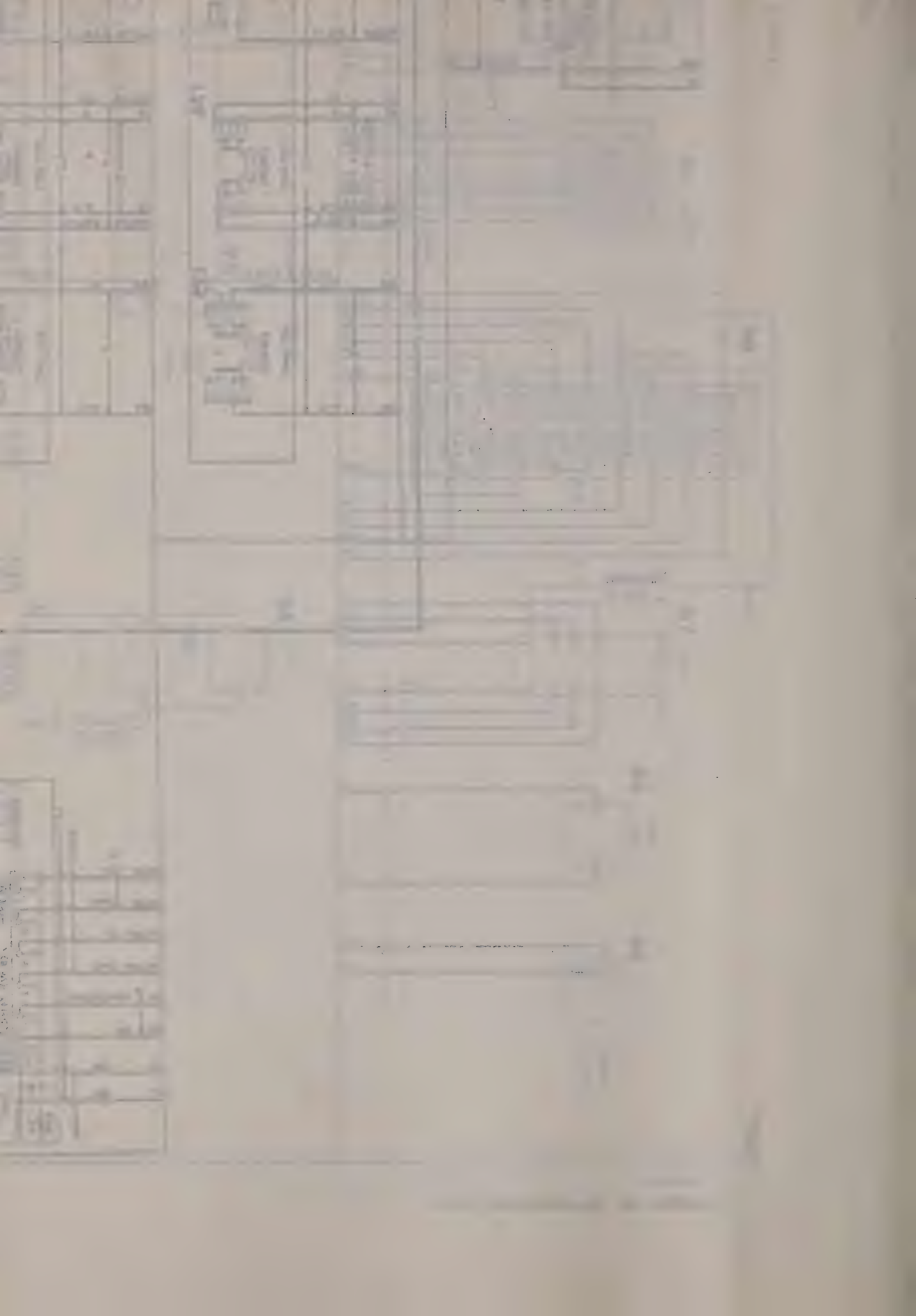
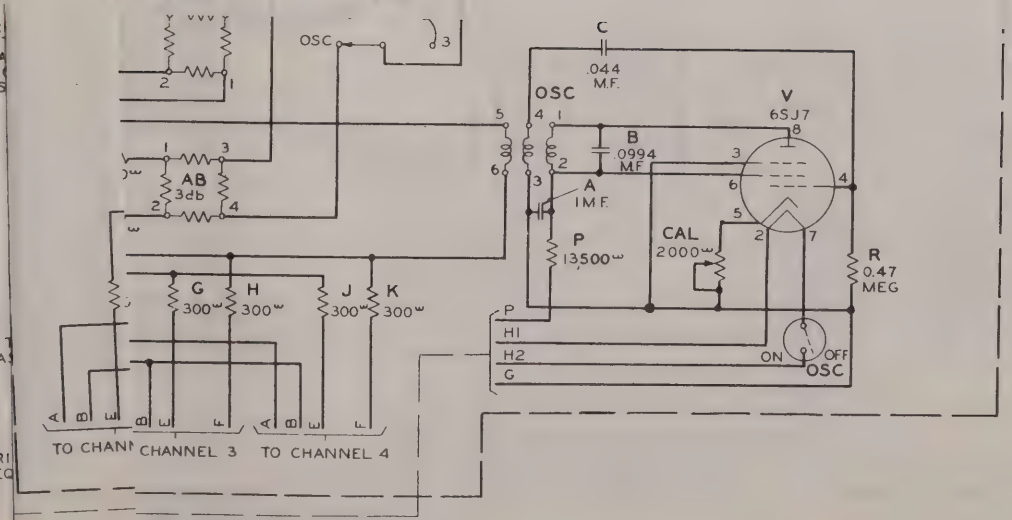
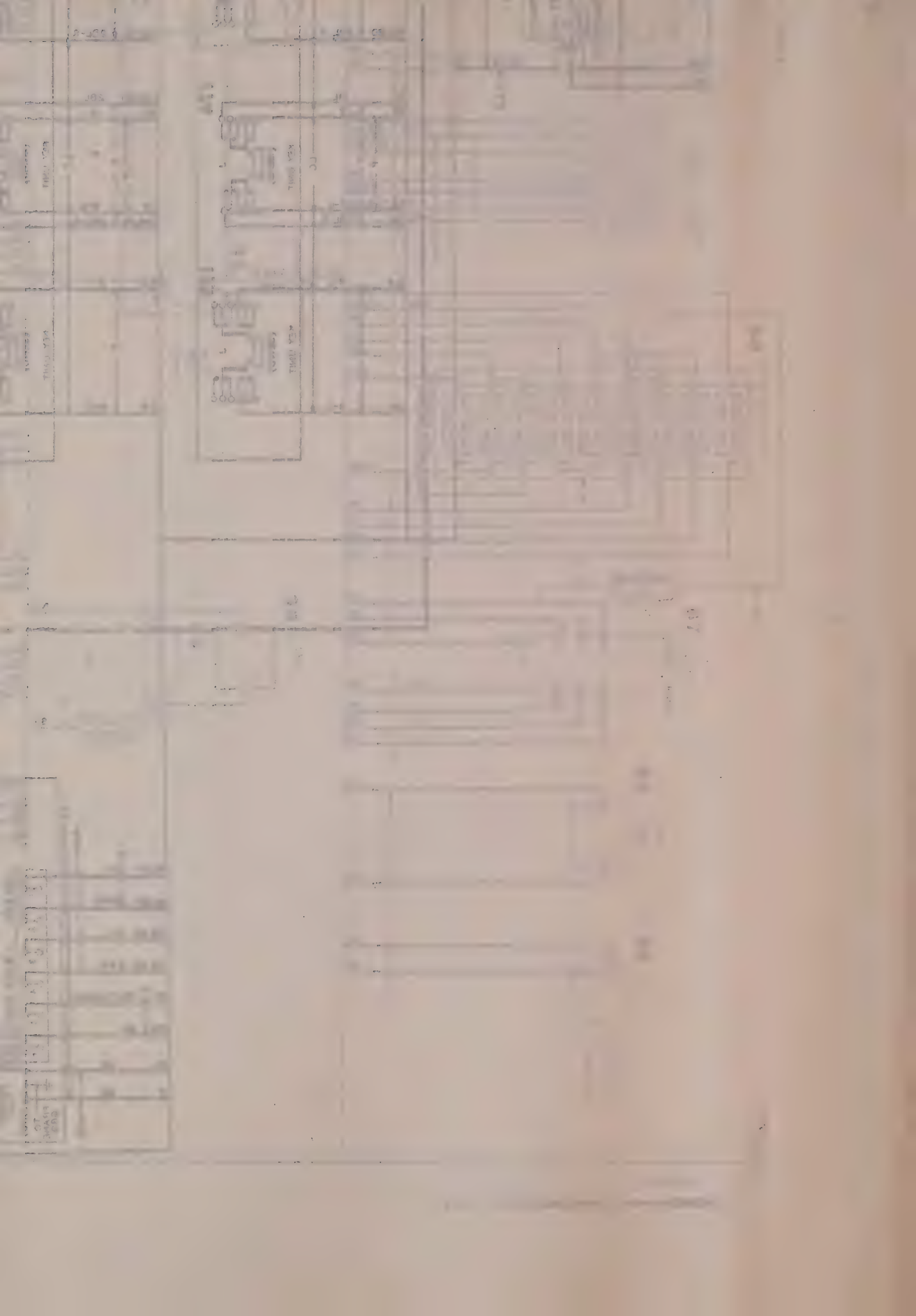


Figure 81. Telephone Terminal CF–1–A (serial numbers below 517), schematic diagram




OSC
C
.044
M.F.
OSC
V
6SJ7
B
.0994
M.F.
A
1 M.F.
AB
3db
P
13,500Ω
CAL
2000Ω
R
0.47
MEG
G
300Ω
H
300Ω
J
300Ω
K
300Ω
P
H1
H2
G
ON
OFF
OSC
TO CHANNEL 3
TO CHANNEL 4
TL52373



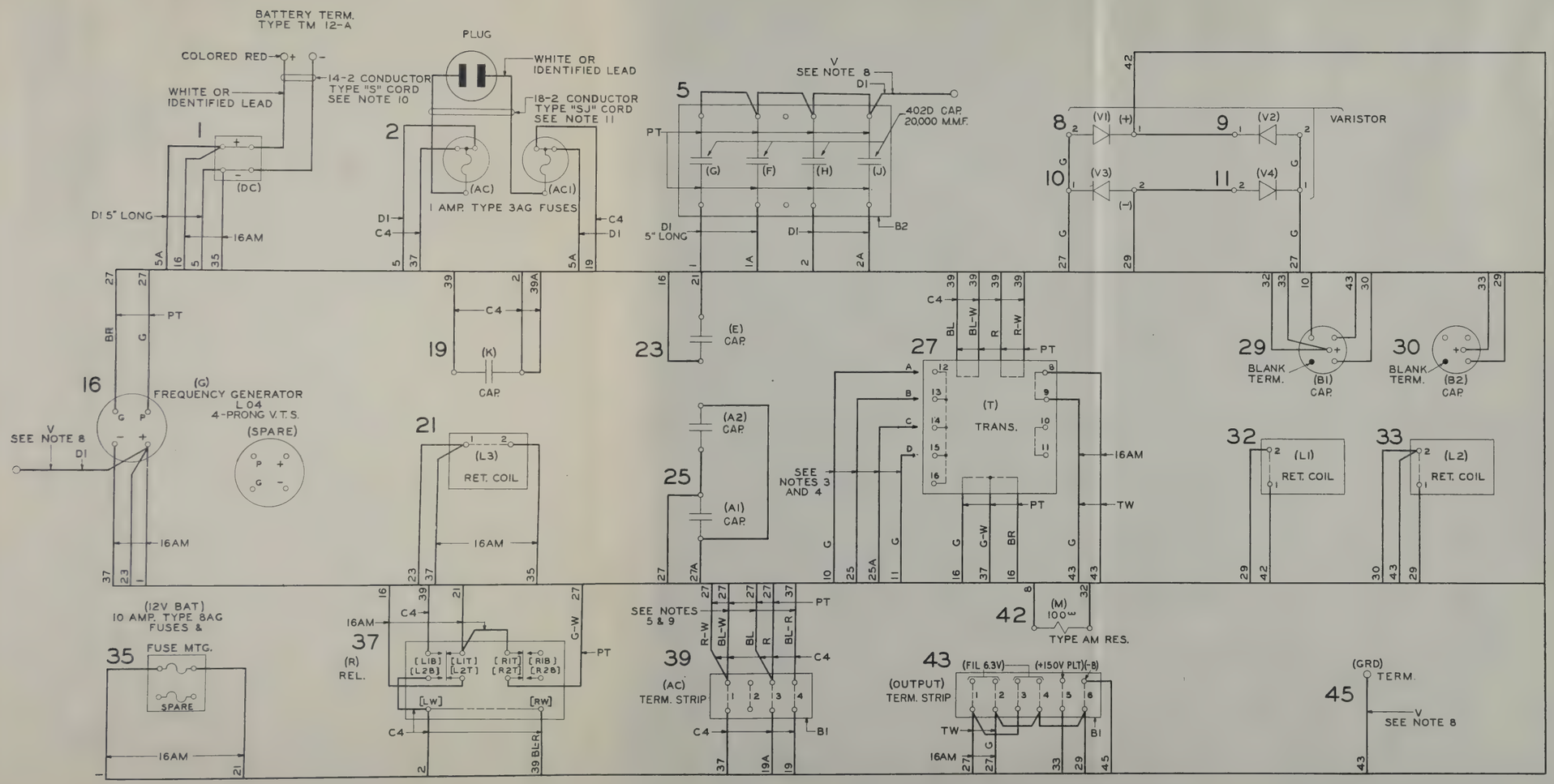


Figure 82. Power supply panel (serial numbers below 880), wiring diagram.

NOTES:

1. WIRES NOT OTHERWISE SPECIFIED ARE D WIRING, 22 TYPE AM BLACK. WIRES SPECIFIED AS 16 AM ARE D WIRING COLORED BLACK.
2. D1 WIRING IS 16 TYPE AM, BLACK, AND UNLESS OTHERWISE SPECIFIED NOT EXCEEDING 3 INCHES IN LENGTH, RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER AND INDEPENDENT OF ALL OTHER LEADS.
3. CONNECTION OF LEADS A-D FROM TRANSFORMER TO RECTIFIER AND (A1) AND (A2) CAPACITORS IS DETERMINED BY SHOP TEST.
4. DESIGNATIONS A, B, C & D ARE STAMPED ON THE TRANSFORMER ADJACENT TO THE TERMINALS TO WHICH THE RESPECTIVE LEADS ARE CONNECTED AS DETERMINED BY SHOP TEST.
5. WIRING SHOWN IS FOR 110-125V., 50-60~ A C. FOR 220-250V., 50-60~ A C CONNECT LEADS AT (AC) TERMINAL STRIP AS FOLLOWS:

LEAD	SHOWN CONNECTED TO TERMINAL	RECONNECT TO TERMINAL
BL	3	2
R-W	1	2
BL-R	4	3

6. C4 WIRING IS FOR COMMERCIAL POWER WITHIN UNIT WHICH MUST BE KEPT SEPARATE FROM OTHER WIRING, AND SHALL BE RUN WITH 16 AM WIRE COLORED BLACK UNLESS OTHERWISE SPECIFIED, SAME AS D WIRING.
7. PT DENOTES LEADS FURNISHED AS PART OF APPARATUS.
8. GROUND LEADS DESIGNATED V SHALL NOT BE CONNECTED TO GROUND TERM OR BINDING POST UNTIL SHOP TEST HAS BEEN COMPLETED.
9. THESE LEADS ARE EQUIPPED WITH LOCKING TERMINALS ON TERMINAL STRIP END.
10. AN IDENTIFICATION TAG STAMPED (12V BAT) IS ATTACHED TO THE CORD.
11. AN IDENTIFICATION TAG STAMPED (AC) IS ATTACHED TO THE CORD.
12. TW DENOTES WIRES TWISTED TOGETHER.
13. B1 DENOTES EDGE OF TERMINAL STRIP NEAREST PANEL.
14. B2 DENOTES EDGE OF CAPACITOR MOUNTING NEAREST REAR OF CASING WHEN MOUNTED.
15. DESIGNATIONS IN [ ] ARE FOR WIRING INFORMATION ONLY.

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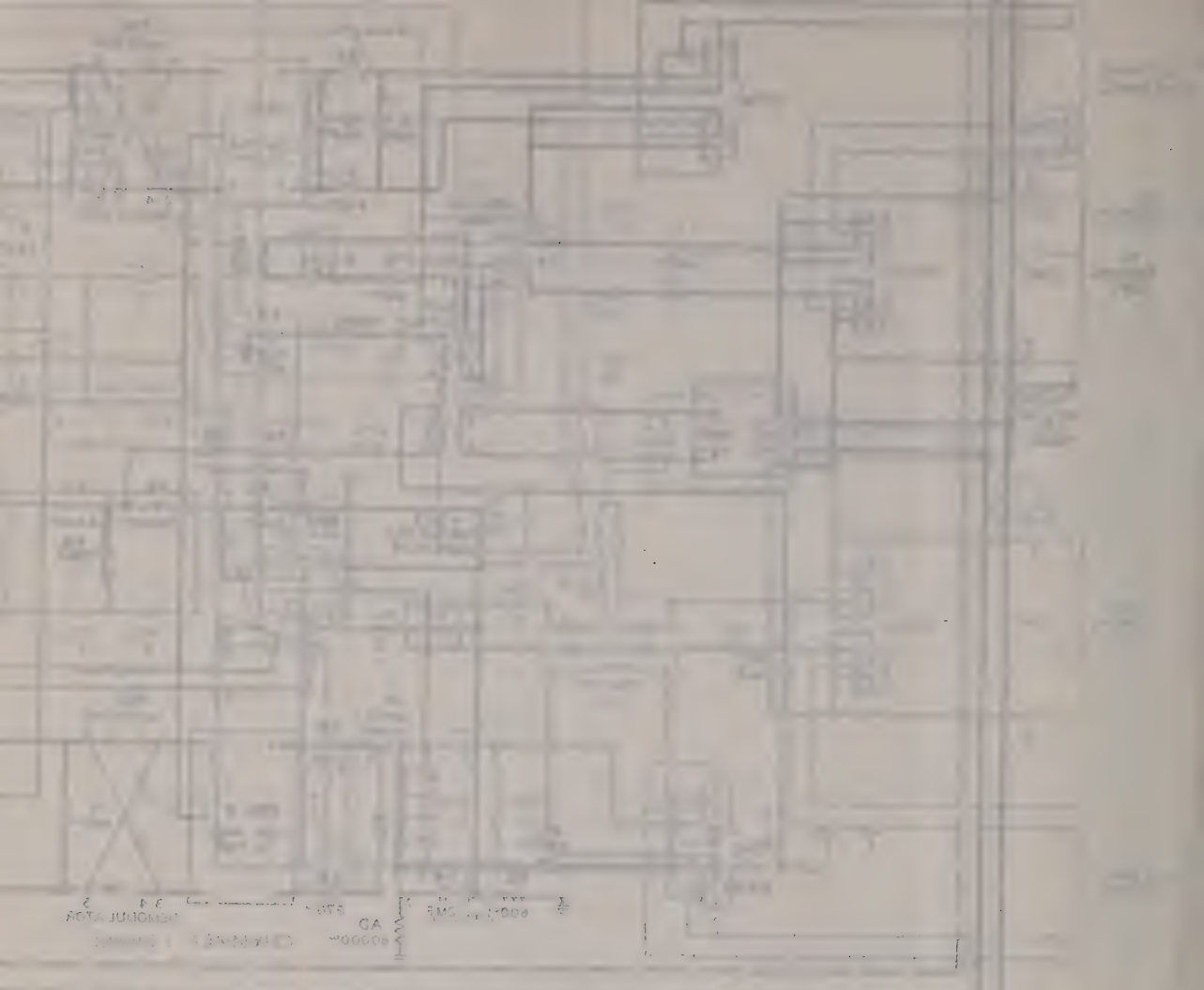
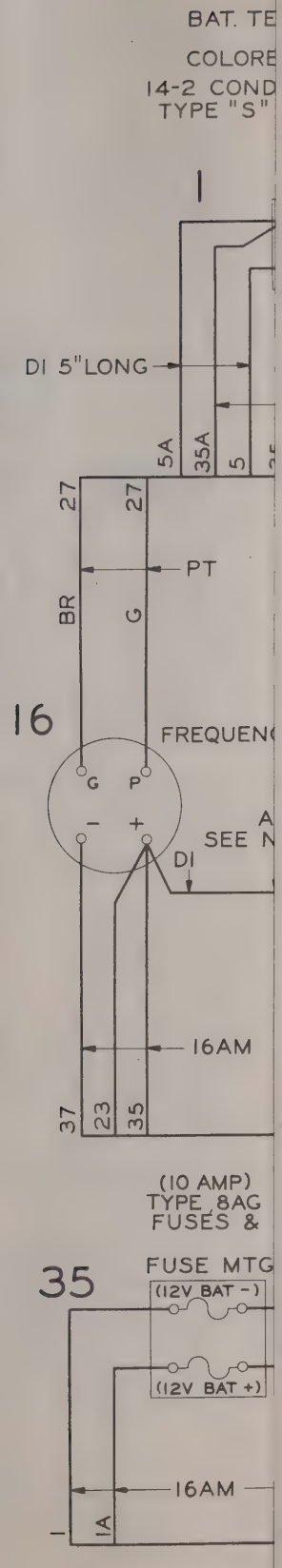
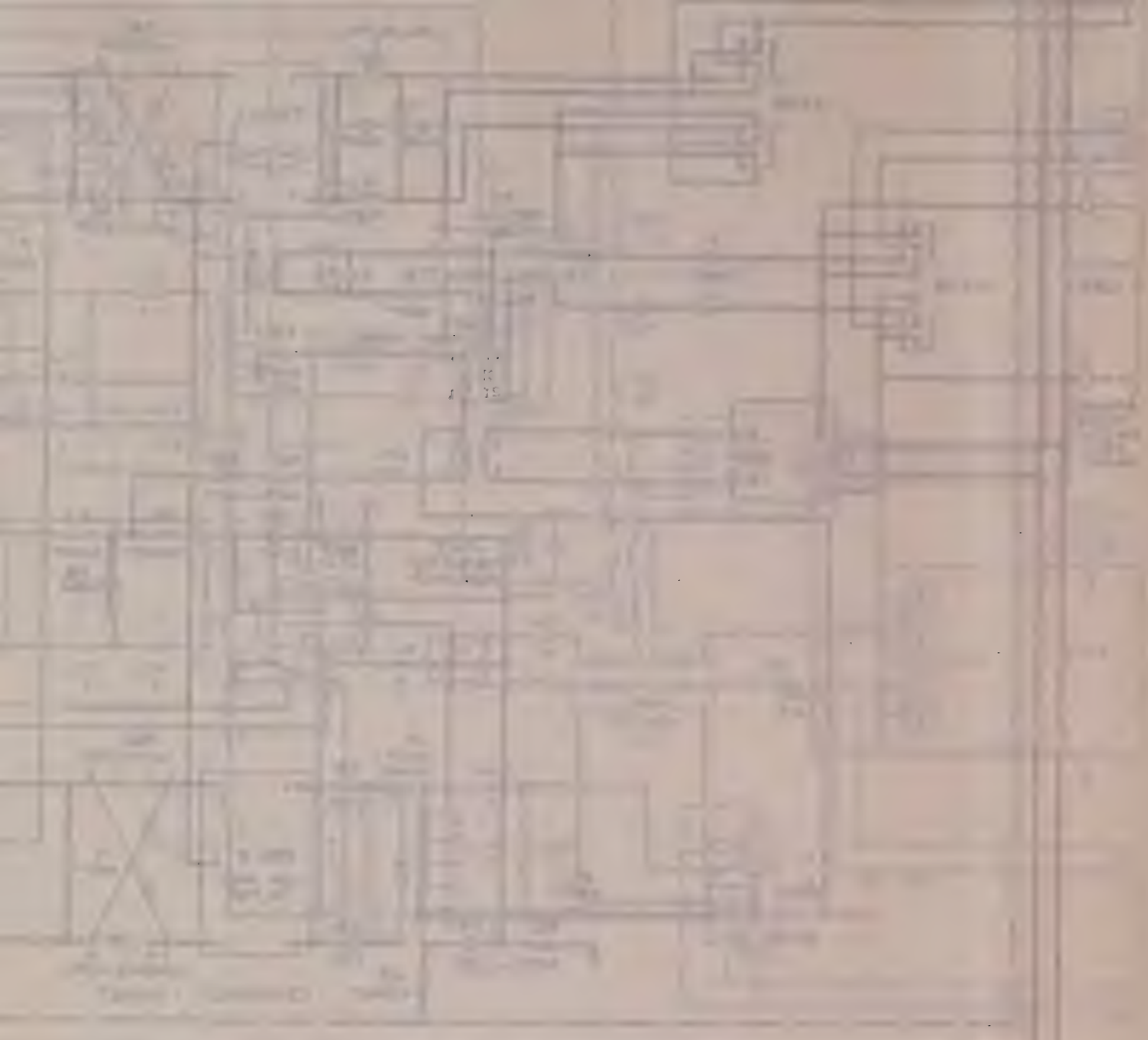



BAT. TE
COLORE
14-2 COND
TYPE "S"
1
DI 5"LONG
5A
35A
5
27
27
PT
BR
G
16
FREQUEN
G
P
I
+
SEE N
DI
16AM
37
23
35
(10 AMP)
TYPE 8AG
FUSES &
35
FUSE MTG
(12V BAT -)
(12V BAT +)
16AM
1A
1



NOTES

1. WIRES NOT OTHERWISE SPECIFIED ARE GREEN 22AM AND UNLESS OTHERWISE SPECIFIED ARE "D3" WIRES.
2. "D3" WIRING IS RUN LOOSE AND DRESSED BACK AGAINST THE MOUNTING PLATE
3. "DI" WIRES RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER
4. "D" WIRES RUN PERPENDICULAR AND PARALLEL TO EDGES OF MOUNTING PLATE IN THE SHORTEST POSSIBLE MANNER
5. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS
6. "GT" DENOTES GROUND TRACER UNDER AND PART OF SHIELD
7. "J" TOP END OF KEY LOOKING AT THE TERMINAL SIDE.
8. "P" DENOTES PAIR
9. "BI" EDGE OF RESISTANCE MOUNTING NEAREST TO PANEL
10. LEADS DESIGNATED "U" ARE 22P SHIELDED WIRES.
11. "B2" TERMINAL NEAREST PANEL.
12. DENOTES SHIELD
13. LEADS DESIGNATED "LC" ARE RUN IN LOCAL CABLE
14. "DI" WIRES ON LINE AMPLIFIER PANEL ARE BLACK 22 AM

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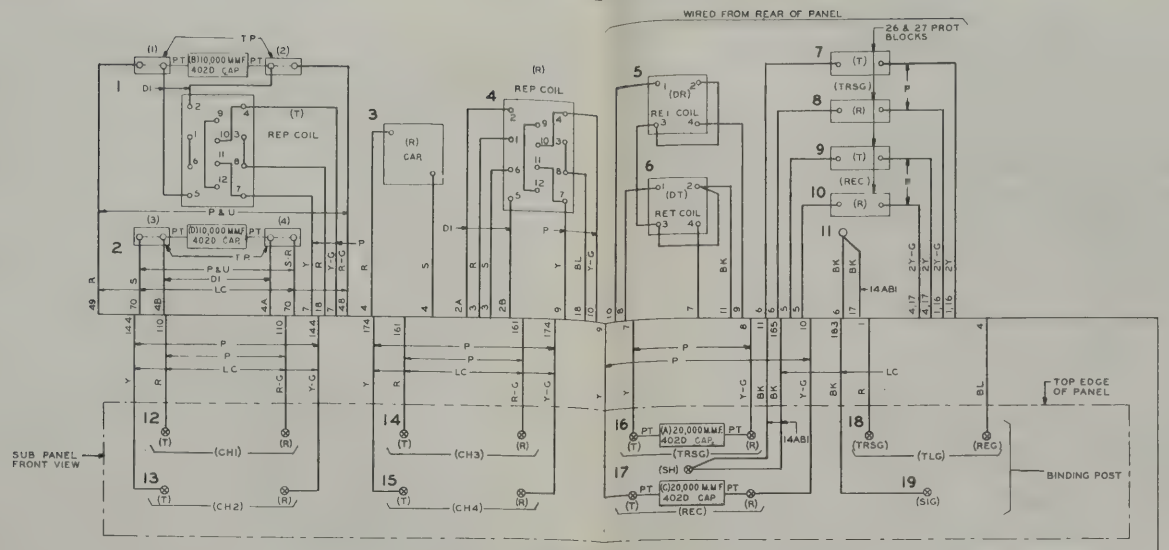
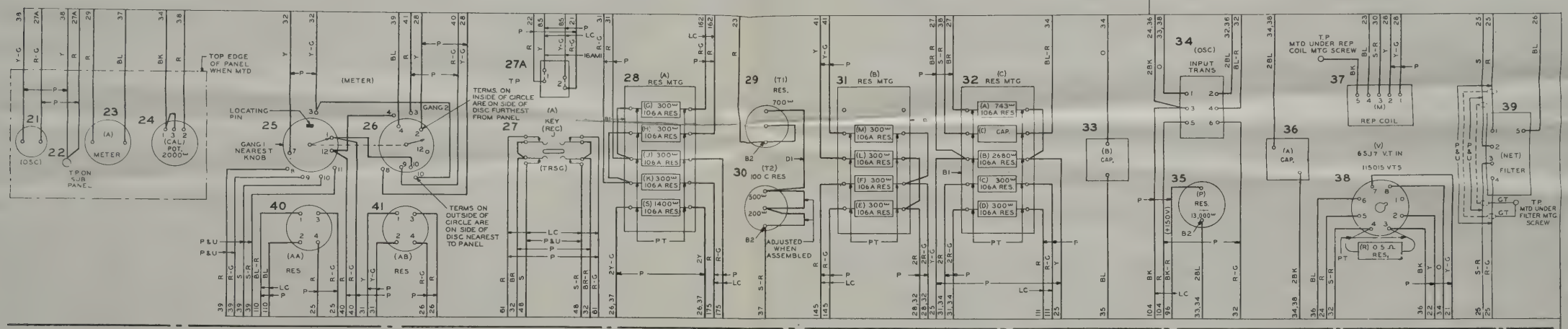
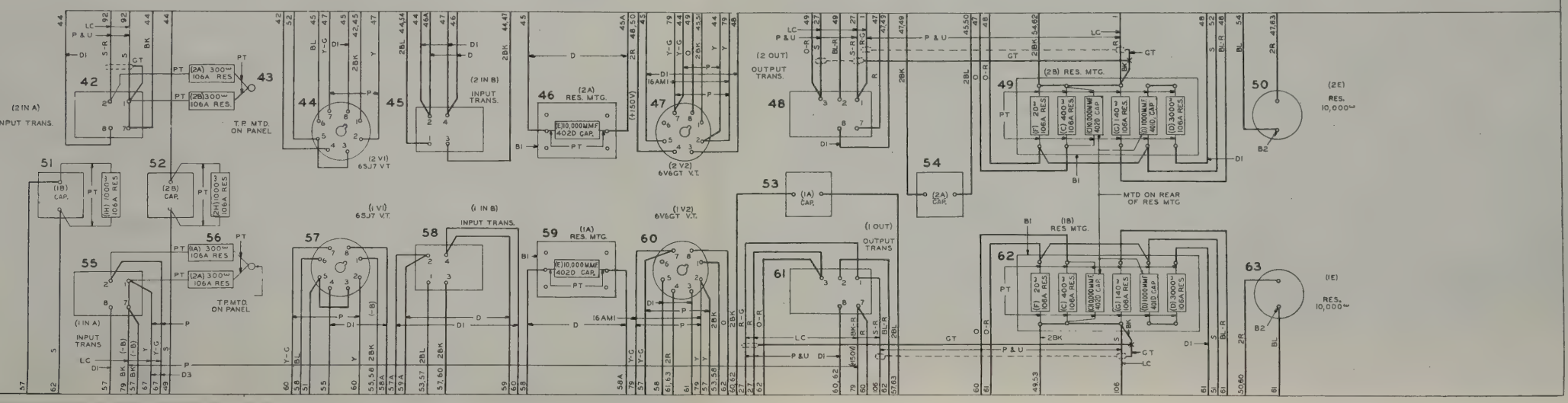
LINE COIL PANEL



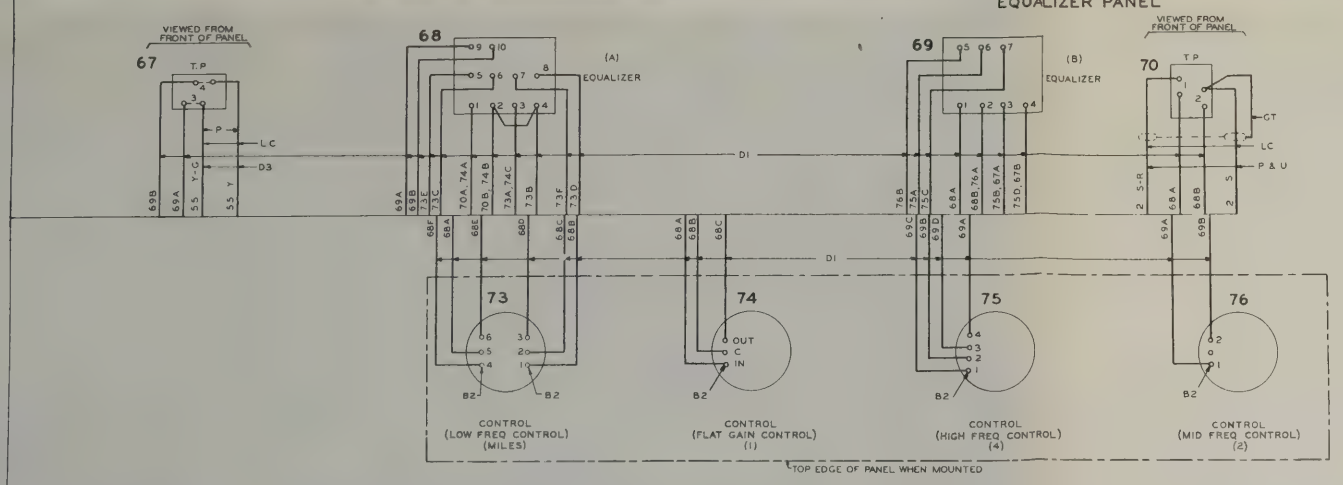
MEASURING PANEL



LINE AMPLIFIER PANEL



EQUALIZER PANEL



POWER SUPPLY PANEL A

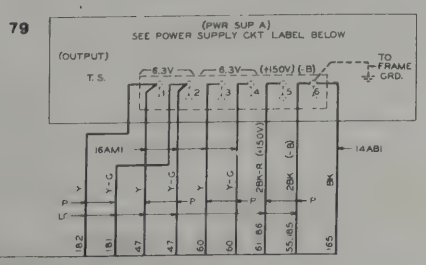
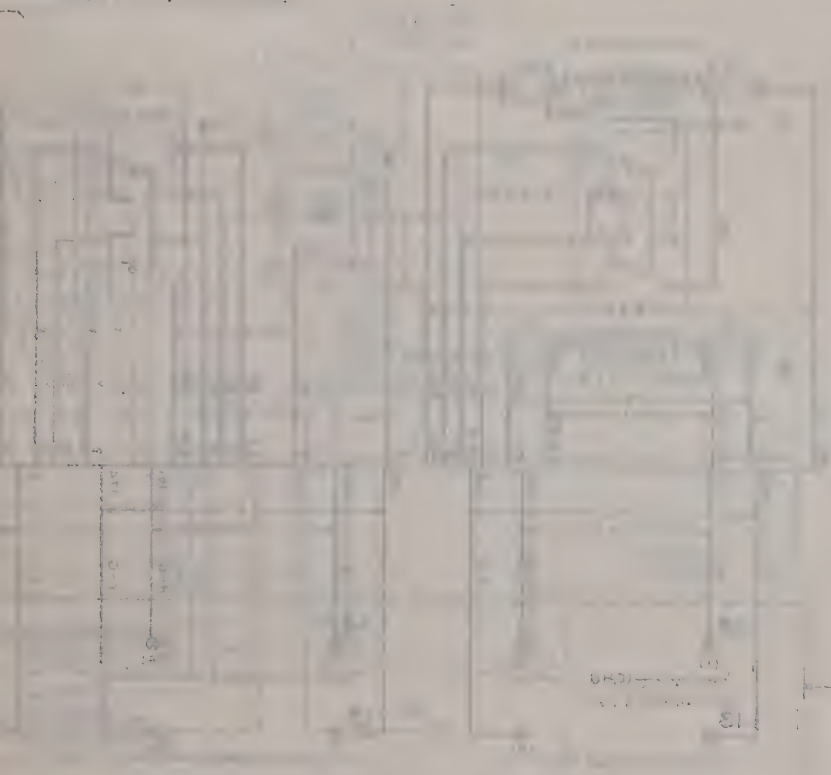
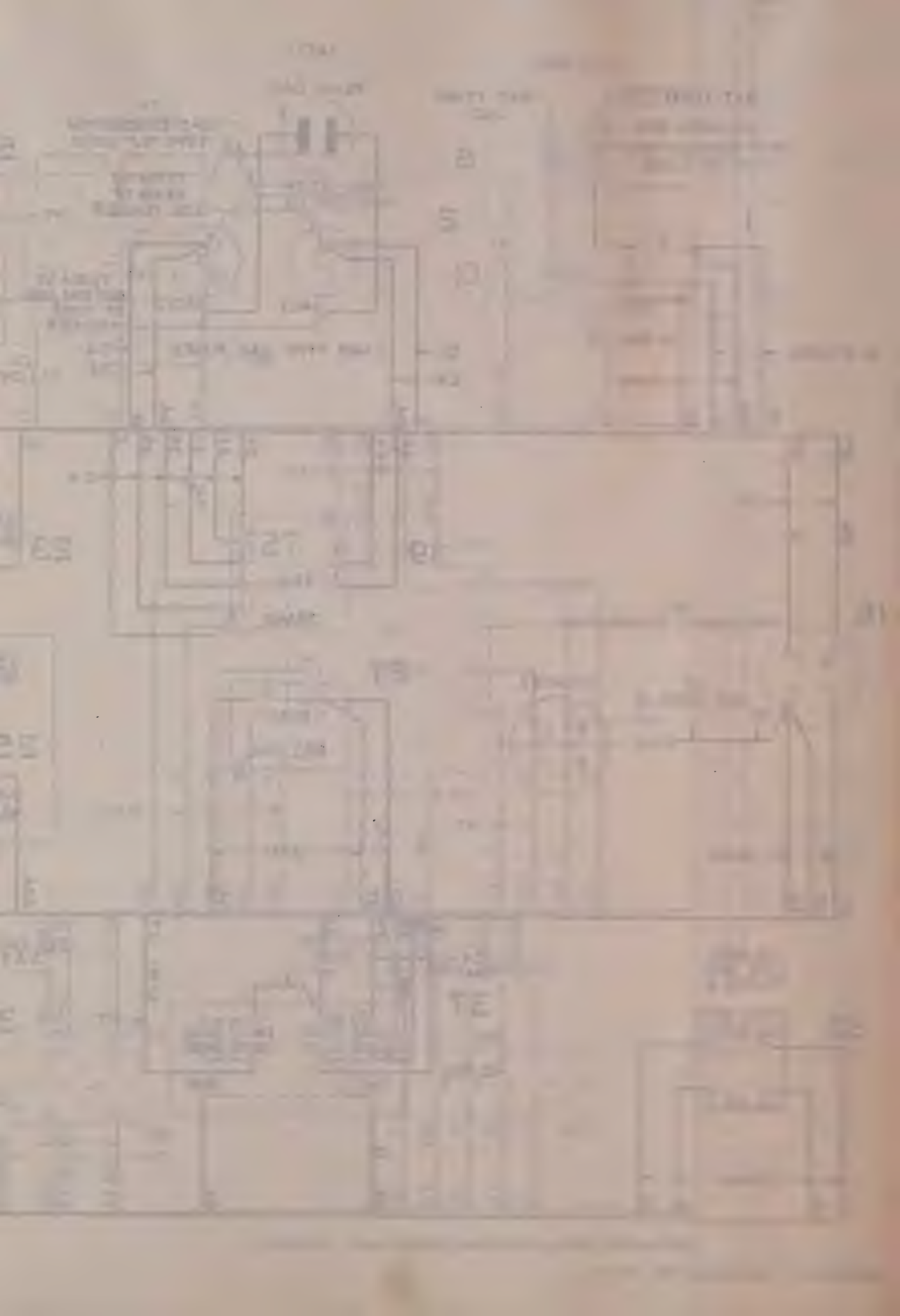


Figure 83. Telephone Terminal CF-1-A (serial numbers below 617), line coil, measuring, line amplifier, and equalizer panels, wiring diagram.





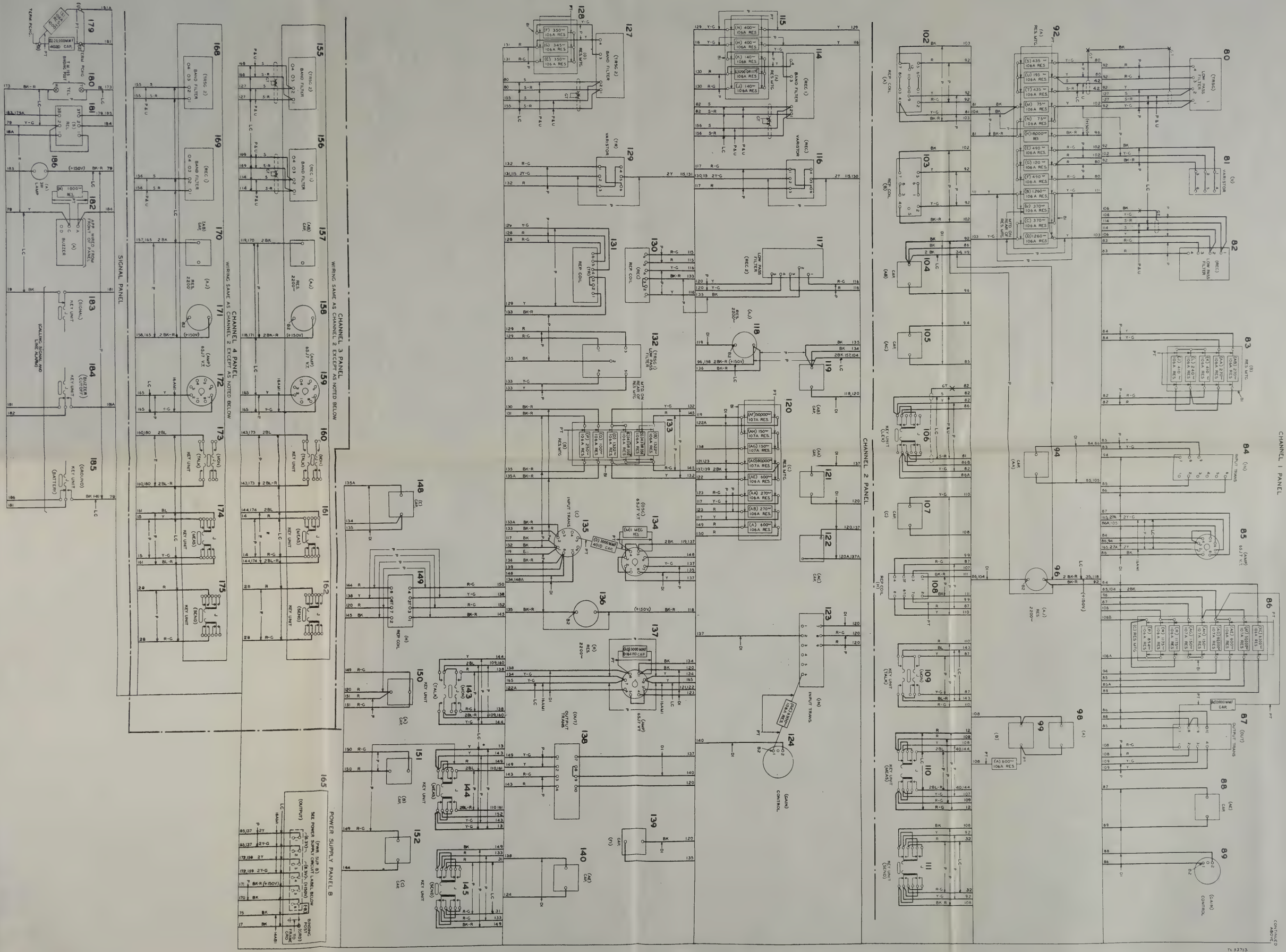
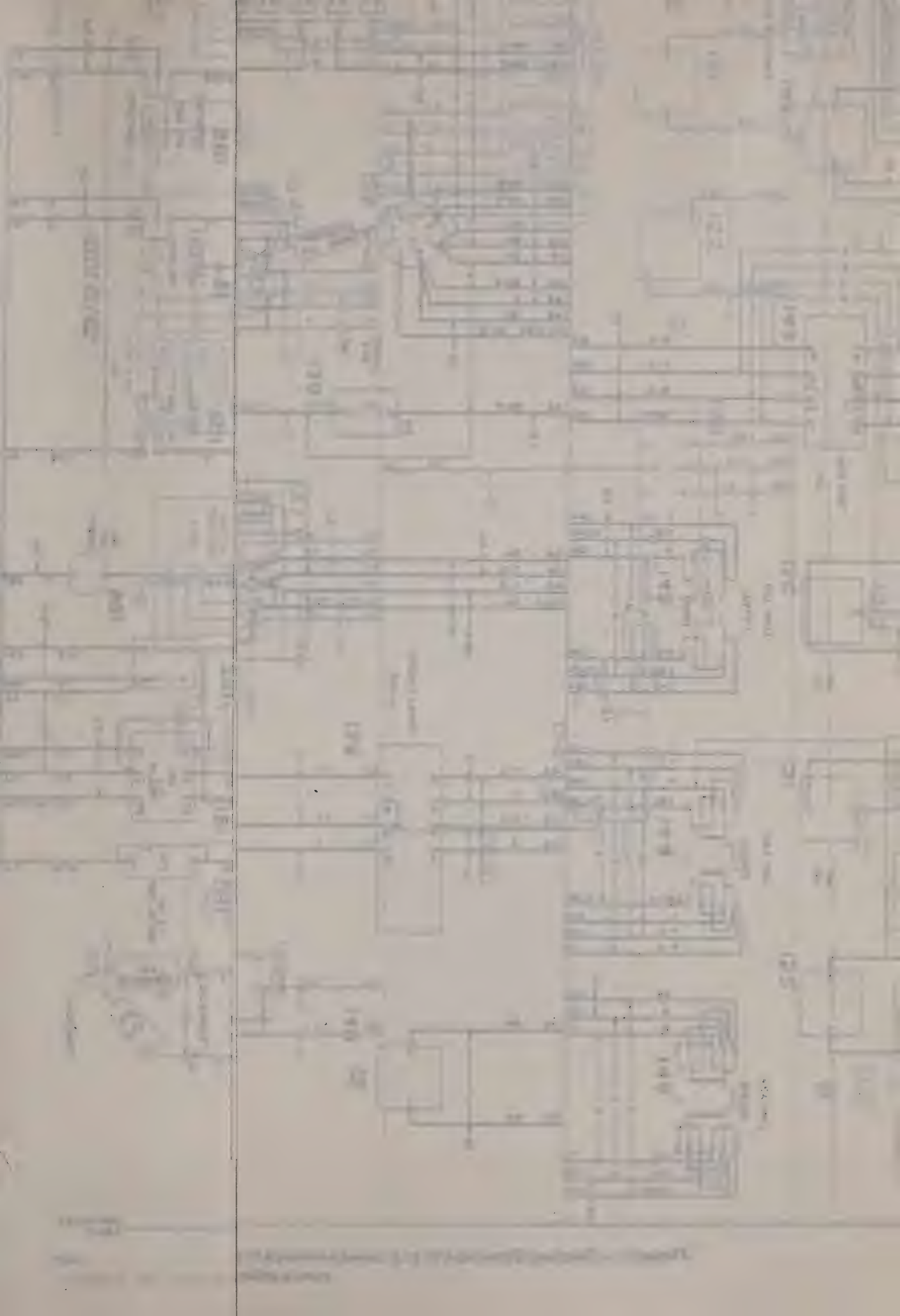
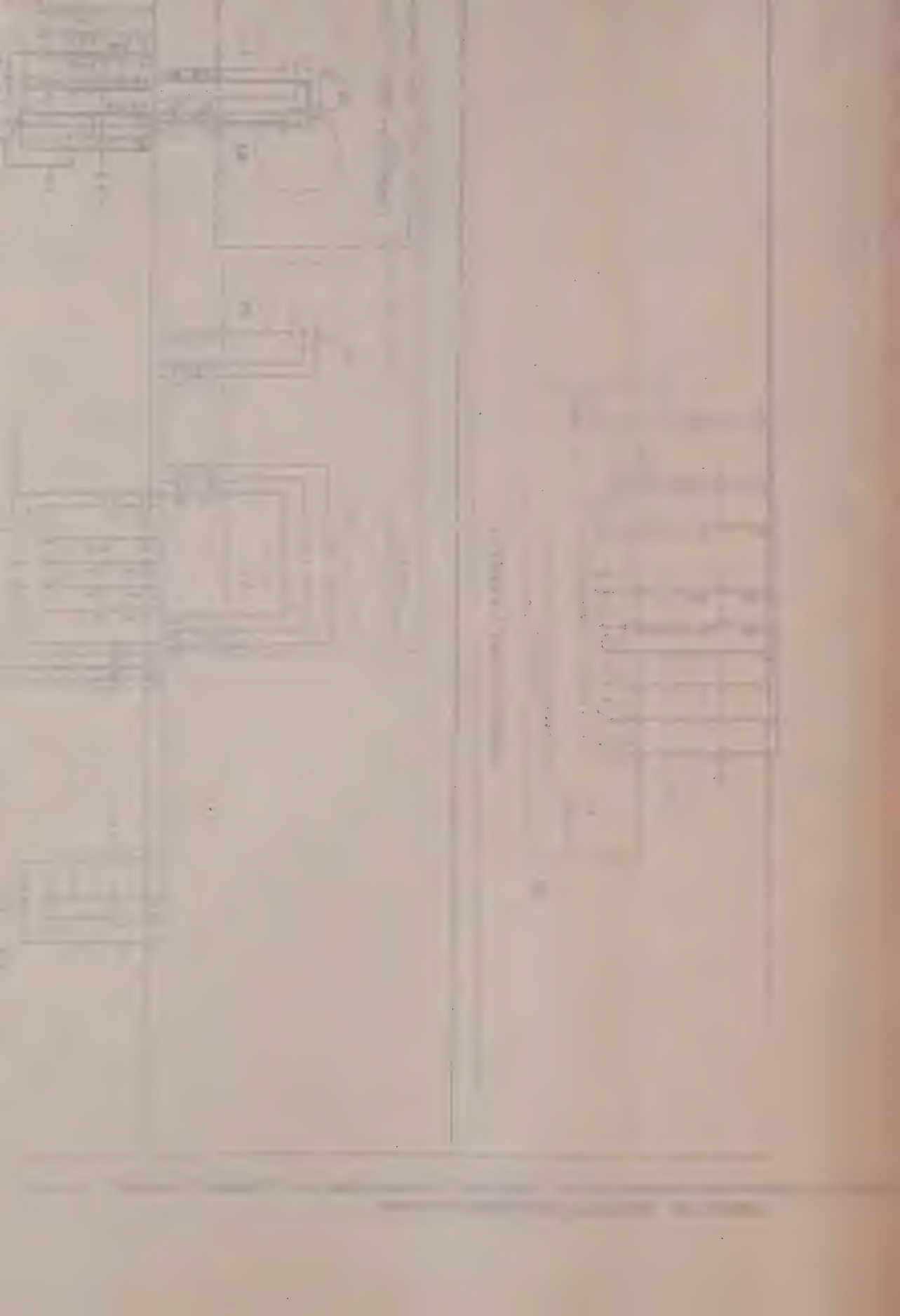


Figure 84. Telephone Terminal CF–1–A (serial numbers below 517), channels 1, 2, 3, and 4, signal, and power supply panels, wiring diagram.





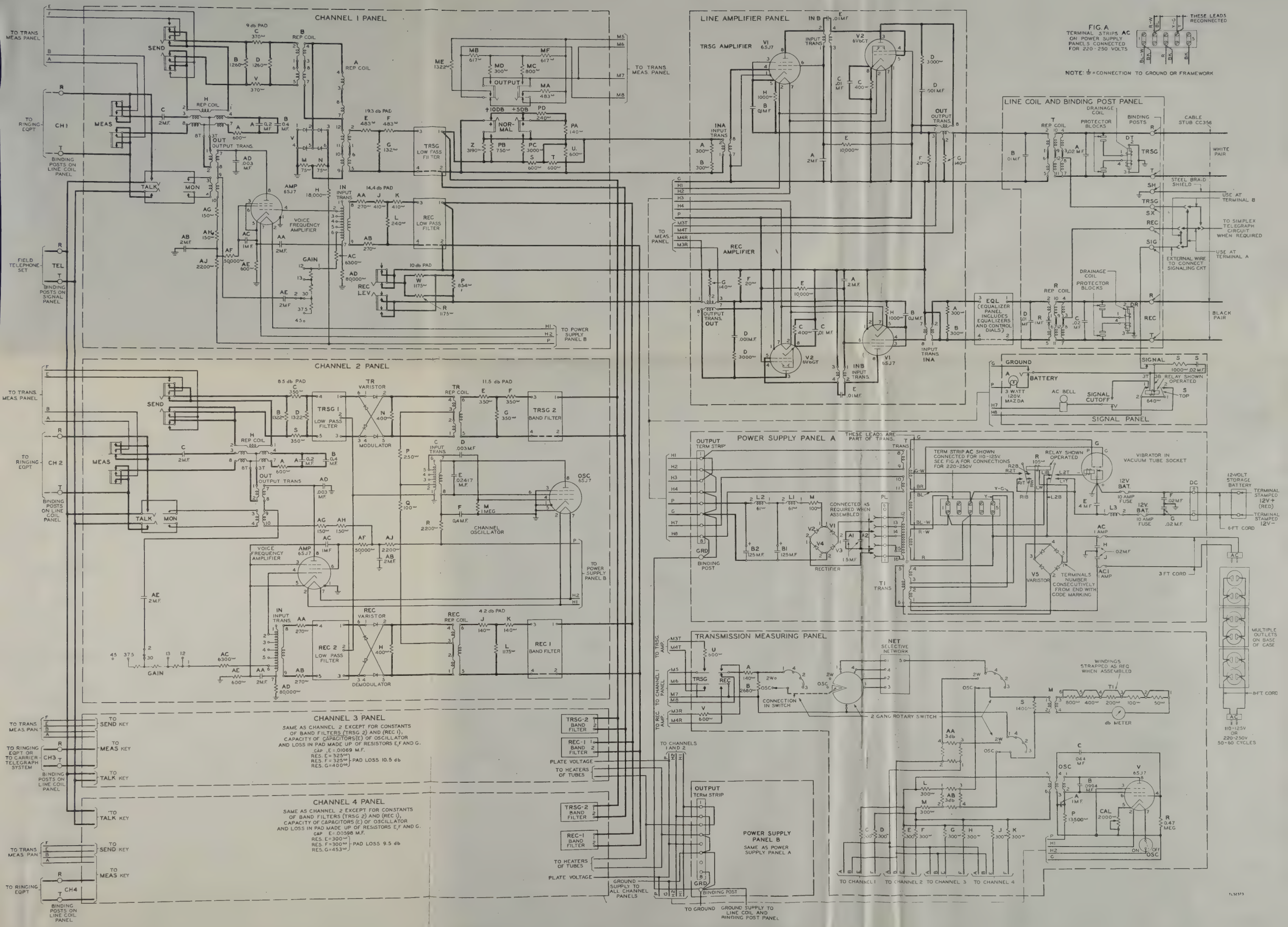
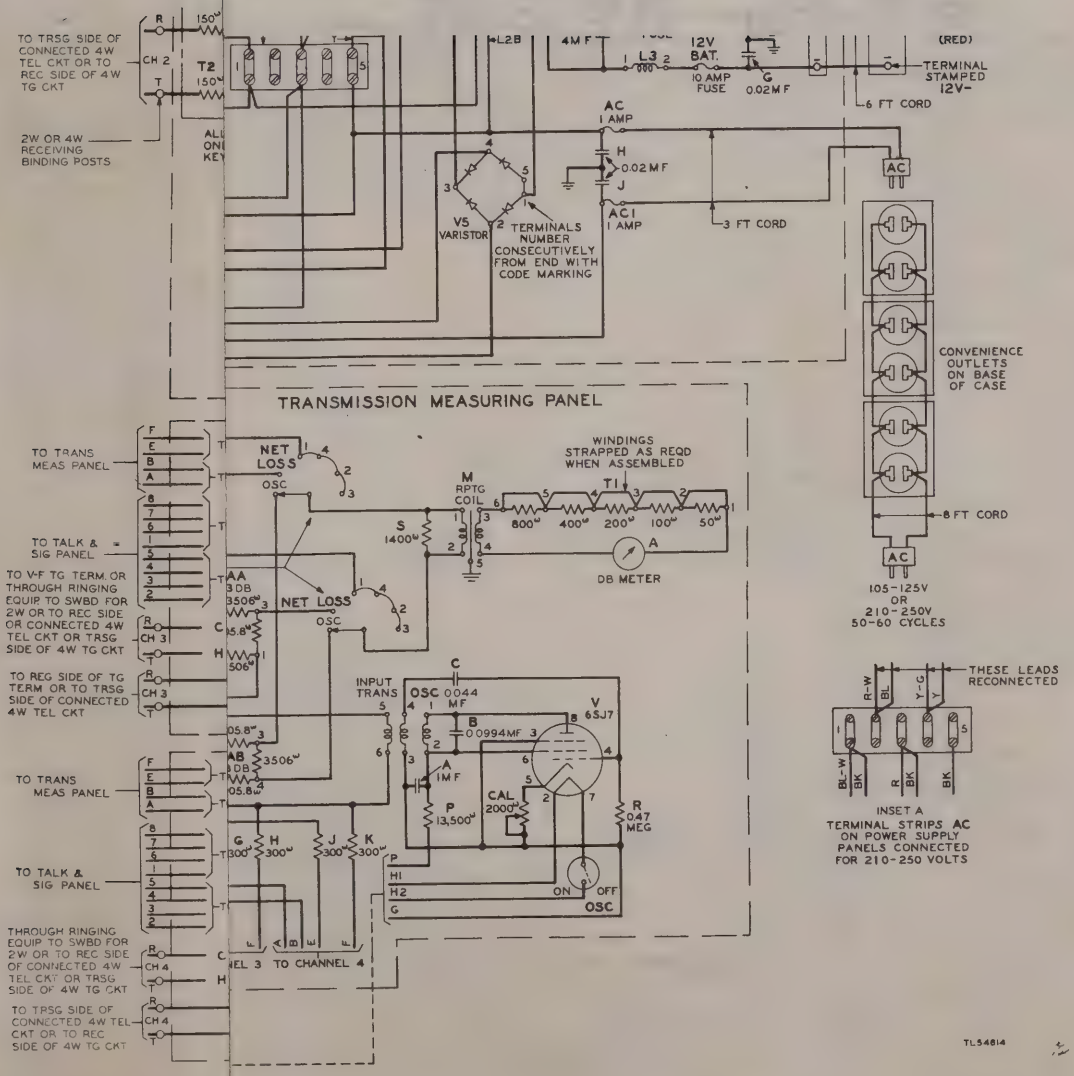


Figure 85. Telephone Terminal CF–1–A (serial numbers 517 and higher), schematic diagram.


TRANSMISSION MEASURING PANEL
TO TRSG SIDE OF CONNECTED 4W TEL CKT OR TO REC SIDE OF 4W TG CKT
2W OR 4W RECEIVING BINDING POSTS
T2
150Ω
L2B
4MF
L3
12V BAT.
10 AMP FUSE
0.02MF
(RED)
TERMINAL STAMPED 12V-
6 FT CORD
AC 1 AMP
H
0.02MF
J
AC1 1 AMP
3 FT CORD
V5 VARISTOR
TERMINALS NUMBER CONSECUTIVELY FROM END WITH CODE MARKING
CONVENIENCE OUTLETS ON BASE OF CASE
8 FT CORD
105-125V OR 210-250V 50-60 CYCLES
TO TRANS MEAS PANEL
TO TALK & SIG PANEL
TO V-F TG TERM. OR THROUGH RINGING EQUIP TO SWBD FOR 2W OR TO REC SIDE OR CONNECTED 4W TEL CKT OR TRSG SIDE OF 4W TG CKT
TO REC SIDE OF TG TERM OR TO TRSG SIDE OF CONNECTED 4W TEL CKT
TO TRANS MEAS PANEL
TO TALK & SIG PANEL
THROUGH RINGING EQUIP TO SWBD FOR 2W OR TO REC SIDE OF CONNECTED 4W TEL CKT OR TRSG SIDE OF 4W TG CKT
TO TRSG SIDE OF CONNECTED 4W TEL CKT OR TO REC SIDE OF 4W TG CKT
NET LOSS
OSC
WINDINGS STRAPPED AS REQD WHEN ASSEMBLED
M RPTG COIL
T1
800Ω 400Ω 200Ω 100Ω 50Ω
S 1400Ω
A
DB METER
AA 3 DB 3506Ω
AB 3 DB 3506Ω
INPUT TRANS
OSC 0044 MF
B 0.0994MF
V 6SJ7
A 1MF
P 13,500Ω
CAL 2000Ω
R 047 MEG
G 300Ω
H 300Ω
J 300Ω
K 300Ω
HI
H2
G
ON
OFF
OSC
THESE LEADS RECONNECTED
INSET A
TERMINAL STRIPS AC ON POWER SUPPLY PANELS CONNECTED FOR 210-250 VOLTS
TL54814

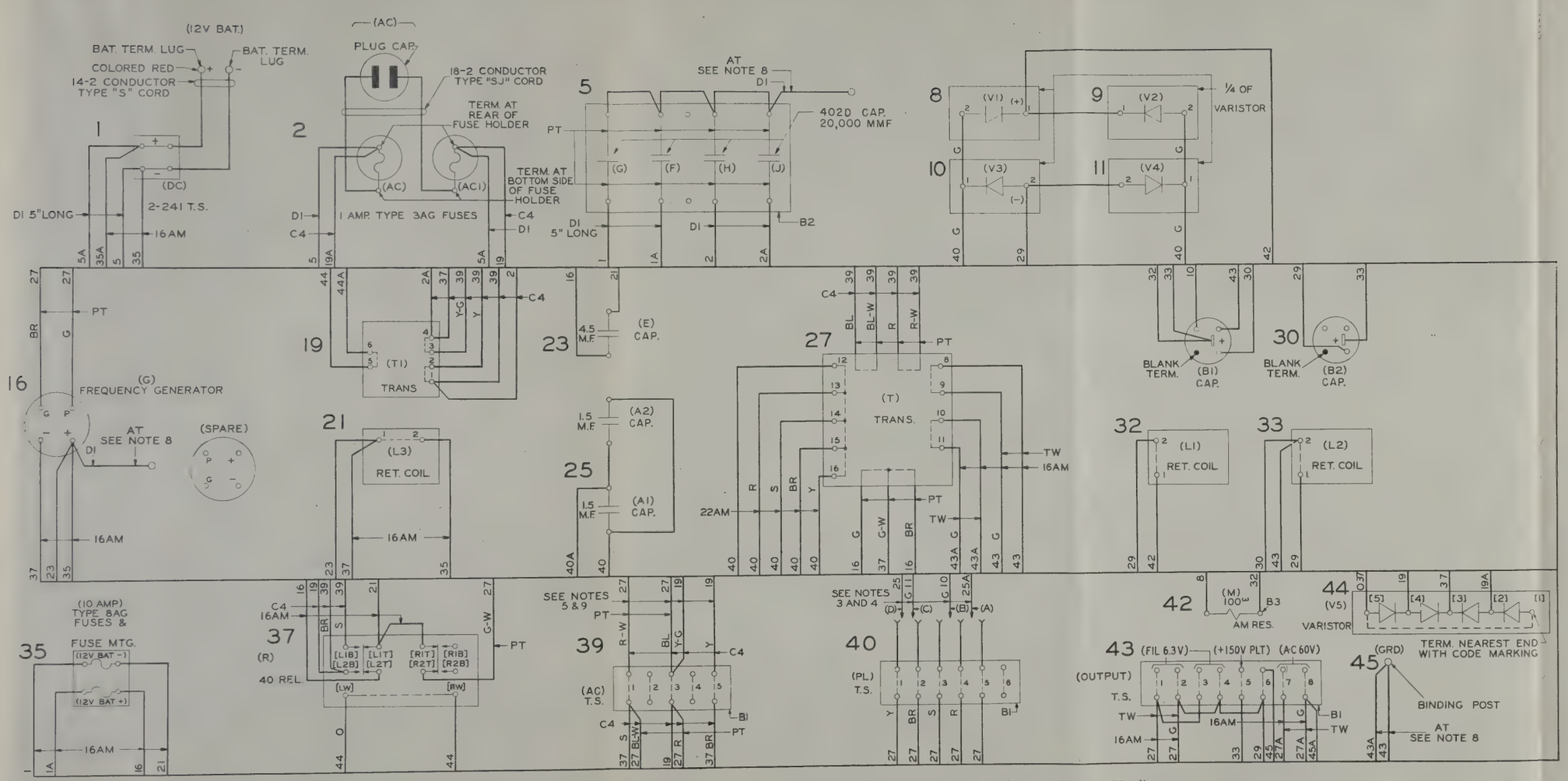


Figure 86. Power supply panel (serial numbers 380 and higher), wiring diagram.

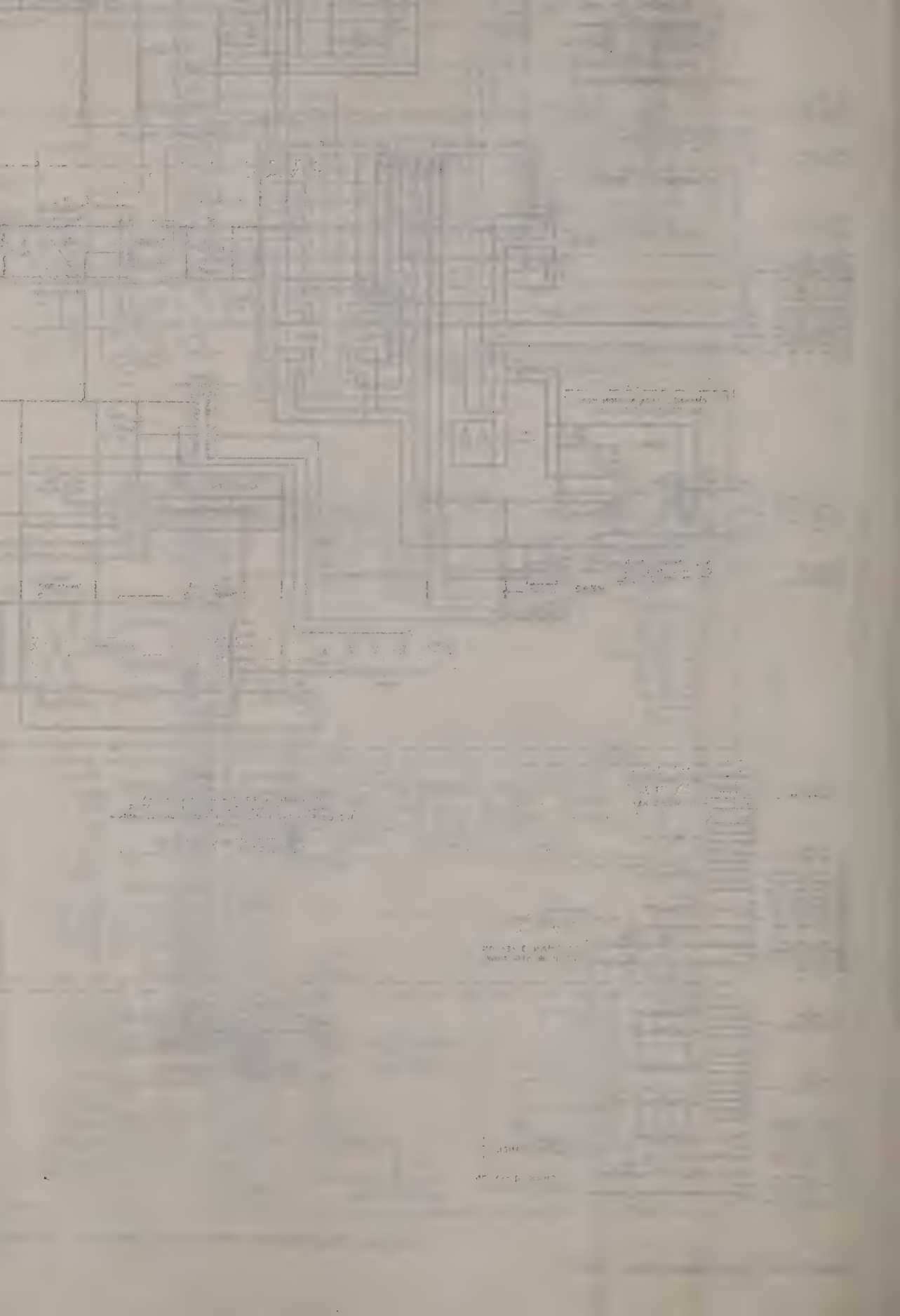
NOTES:

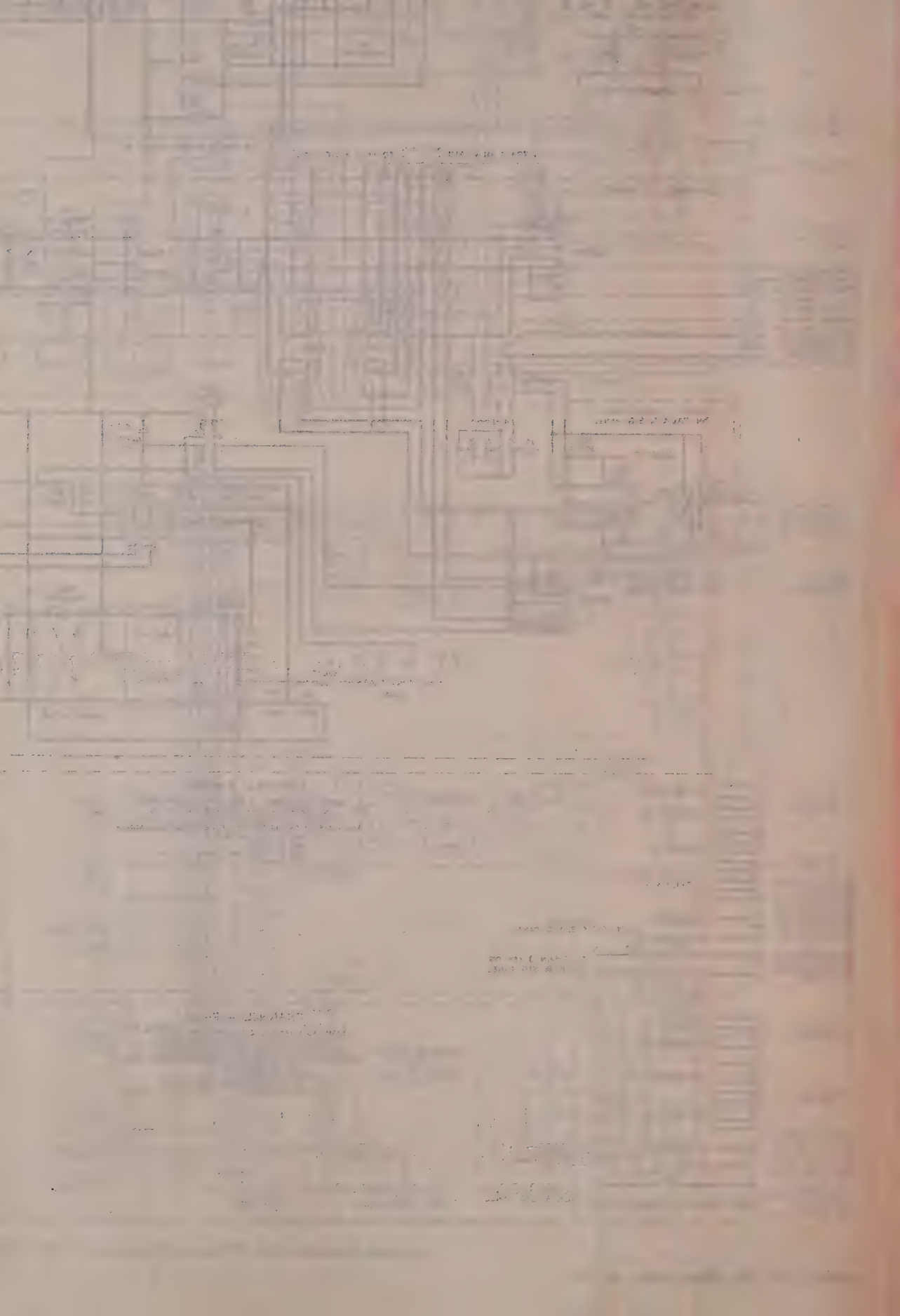
1. WIRES NOT OTHERWISE SPECIFIED ARE "D" WIRING, 22 TYPE AM BLACK. WIRES SPECIFIED AS 16AM ARE "D" WIRING COLORED BLACK UNLESS OTHERWISE SPECIFIED.
2. "DI" WIRING IS 16 TYPE AM, BLACK, AND UNLESS OTHERWISE SPECIFIED NOT EXCEEDING 3 INCHES IN LENGTH, RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER AND INDEPENDENT OF ALL OTHER LEADS.
3. CONNECTION OF LEADS FROM TERMINAL STRIP (PL) TO VARISTORS (V3) AND (V4) AND CAPACITOR (A1) AND (A2) IS DETERMINED BY SHOP TEST.
4. DESIGNATIONS A, B, C, & D, ARE STAMPED ON THE TOP OF THE (PL) TERMINAL STRIP ADJACENT TO THE TERMINALS TO WHICH THE RESPECTIVE LEADS ARE CONNECTED AS DETERMINED BY SHOP TEST.
5. WIRING SHOWN IS FOR 110-125V, 50-60~A-C. FOR 220-250V, 50-60~A-C CONNECT LEADS AT (AC) TERMINAL STRIP AS FOLLOWS:

LEAD	SHOWN CONNECTED TO TOP TERMINAL	RECONNECT TO TOP TERMINAL
BL	3	2
R-W	1	2
Y-G	3	4
Y	5	4

6. "C4" WIRING IS FOR COMMERCIAL POWER WITHIN UNIT WHICH MUST BE KEPT SEPARATE FROM OTHER WIRING, AND RUN WITH 16 AM WIRE COLORED BLACK UNLESS OTHERWISE SPECIFIED, SAME AS "D" WIRING.
7. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS.
8. GROUND LEADS DESIGNATED "AT" SHALL NOT BE CONNECTED TO GROUND TERMINAL PUNCHINGS OR BINDING POST UNTIL SHOP TEST HAS BEEN COMPLETED.
9. THESE LEADS ARE EQUIPPED WITH SHAKEPROOF LOCKING TERMINALS NO. 2108-6 ON TERMINAL STRIP END.
10. THE POSITIVE AND NEGATIVE BATTERY TERMINAL LUGS ARE IDENTIFIED BY MEANS OF (12V+) AND (12V−) DIE STAMPED ON THE RESPECTIVE LUGS.
11. ON TWO SIDES OF THE METALLIC CASING OF THE ATTACHMENT PLUG, THE LETTERS (AC) ARE ENGRAVED TO IDENTIFY THE AC CORD.
12. "TW" DENOTES WIRES TWISTED TOGETHER.
13. "B1" DENOTES EDGE OF TERMINAL STRIP NEAREST PANEL.
14. "B2" DENOTES EDGE OF CAPACITOR MOUNTING NEAREST REAR OF CASING WHEN MOUNTED.
15. DESIGNATIONS IN [ ] ARE FOR WIRING INFORMATION ONLY.
16. "B3" DENOTES TERM. NEAREST MTG. PANEL WHEN D-162753 RES. IS USED.
17. — — — DENOTES STD. STRAPPING FURNISHED WITH APPARATUS.

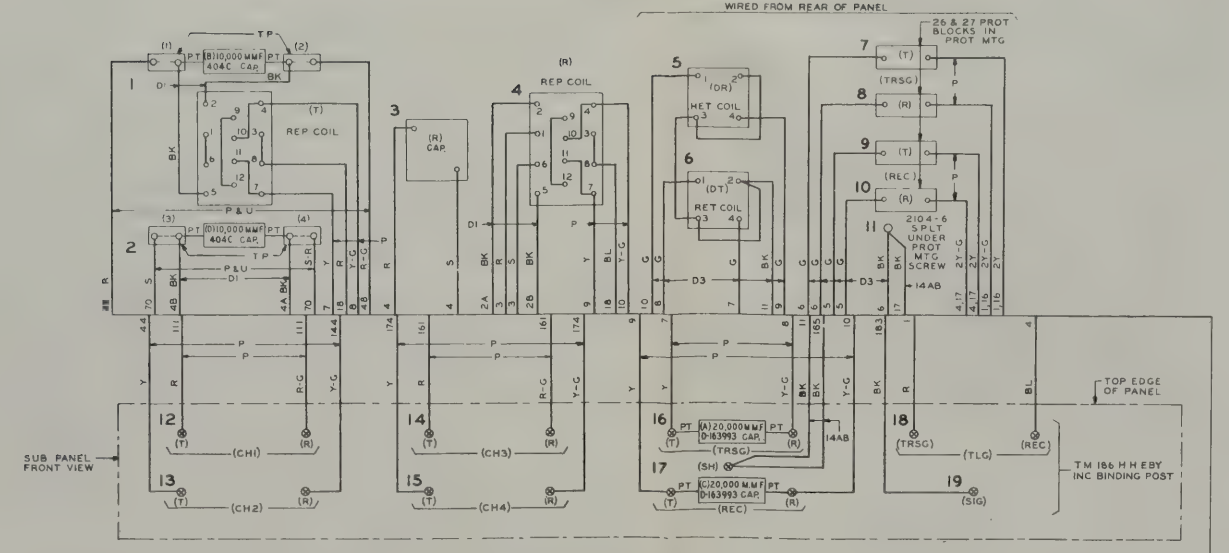
TL 53583-S



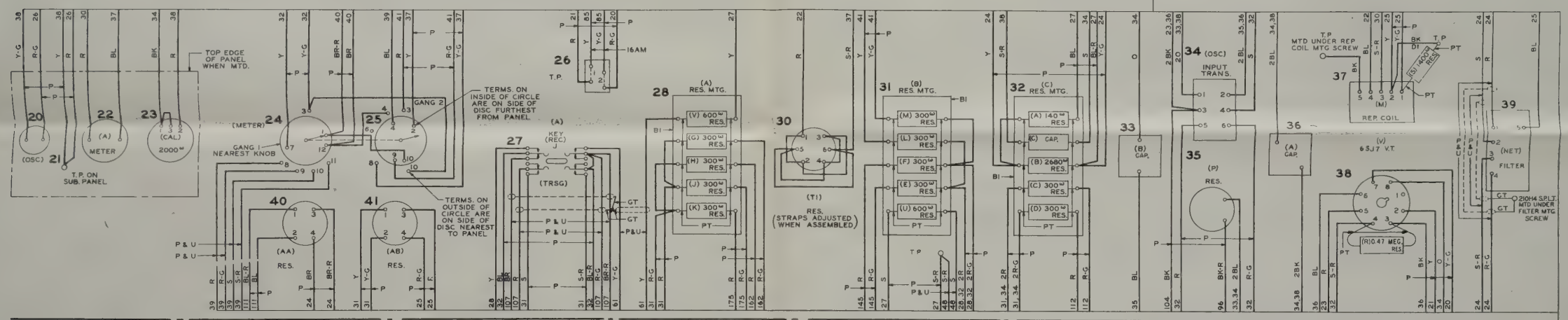


NOTES:
1. WIRES NOT OTHERWISE SPECIFIED ARE 22AM
2. "D3" WIRING IS RUN LOOSE AND DRESSED BACK AGAINST THE MOUNTING PLATE
3. "DI" WIRES RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER
4. "D" WIRES RUN PERPENDICULAR AND PARALLEL TO EDGES OF MOUNTING PLATE IN THE SHORTEST POSSIBLE MANNER
5. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS
6. "GT" DENOTES GROUND TRACER UNDER AND PART OF SHIELD
7. "J" TOP END OF KEY LOOKING AT THE TERMINAL SIDE
8. "P" DENOTES PAIR
9. "BI" EDGE OF RESISTANCE MOUNTING NEAREST TO PANEL
10. LEADS DESIGNATED "U" ARE 22P SHIELDED WIRES
11. "82" TERMINAL NEAREST PANEL
12. ⊂⊃ DENOTES SHIELD
13. ALL STRAPS ARE BLACK 22AM EXCEPT WHERE BARE STRAPS ARE PERMISSIBLE.
14. —✕— DENOTES SPLICE.

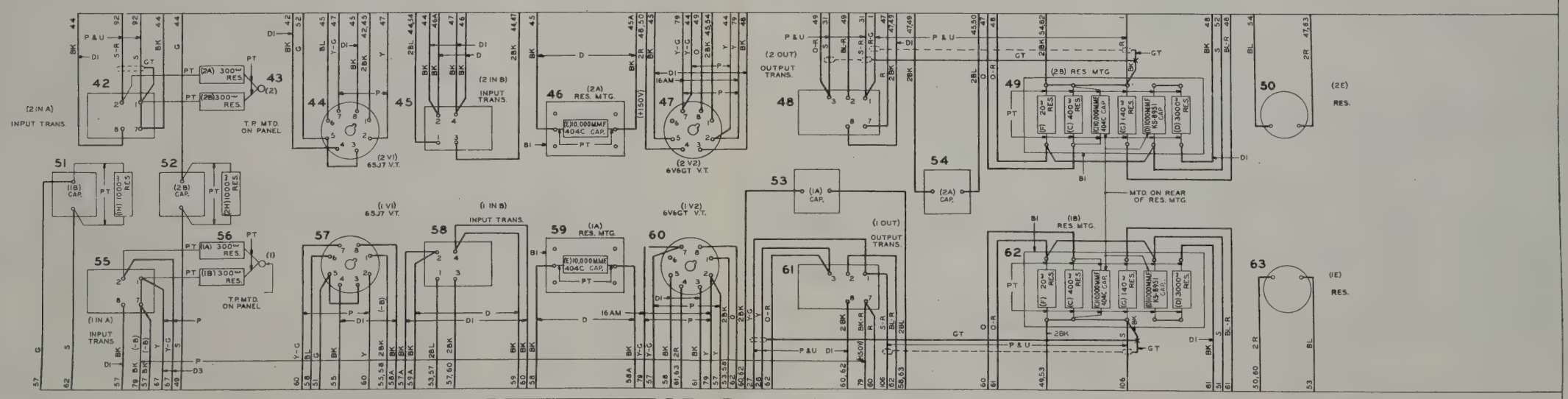
LINE COIL PANEL



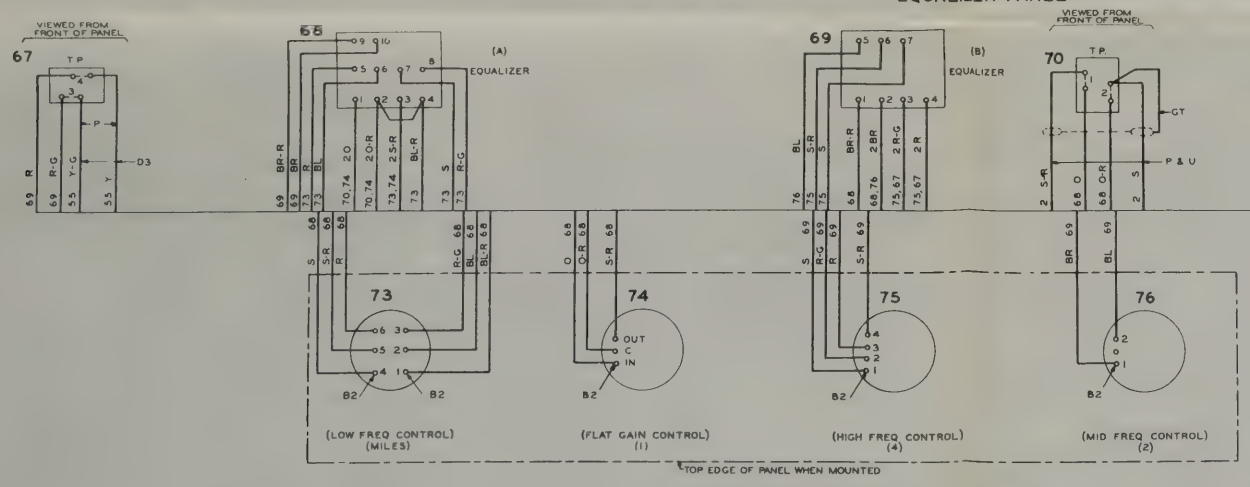
MEASURING PANEL



LINE AMPLIFIER PANEL



EQUALIZER PANEL



POWER SUPPLY PANEL A

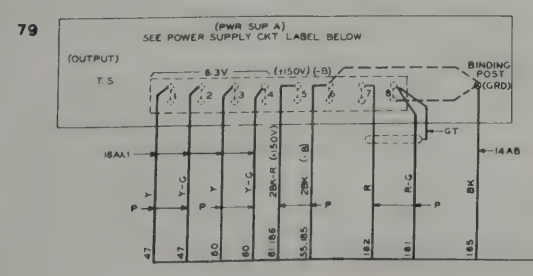
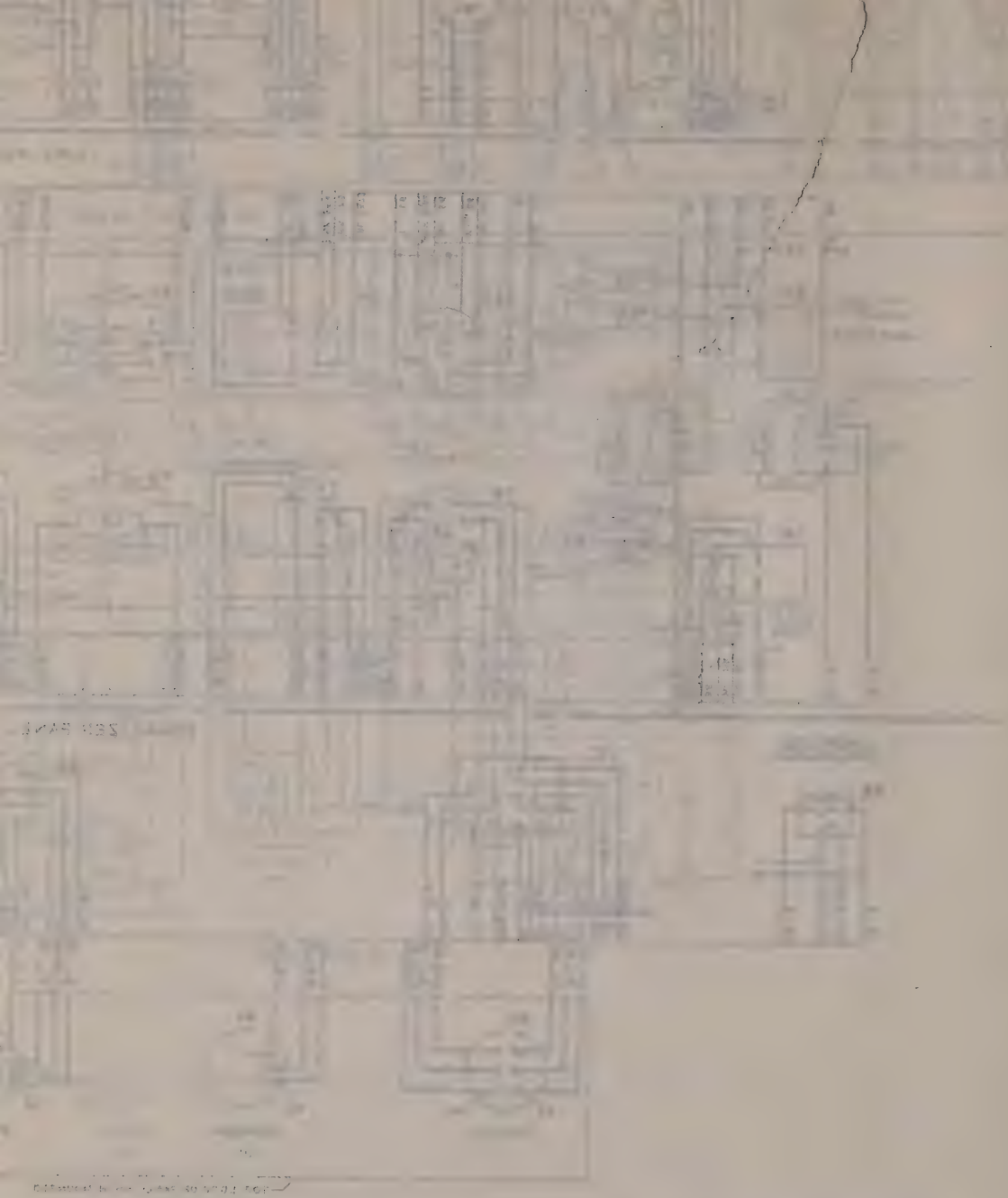
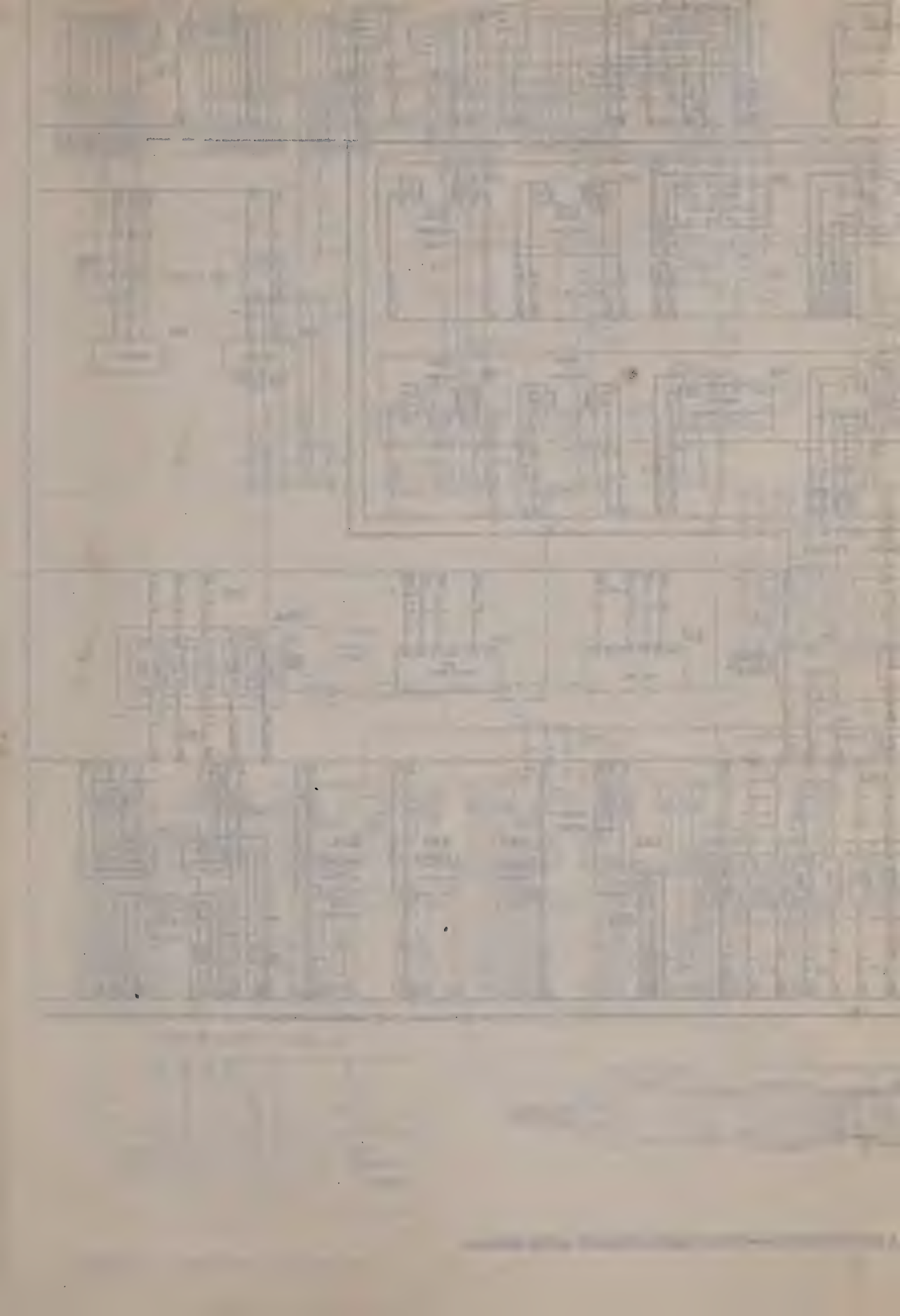
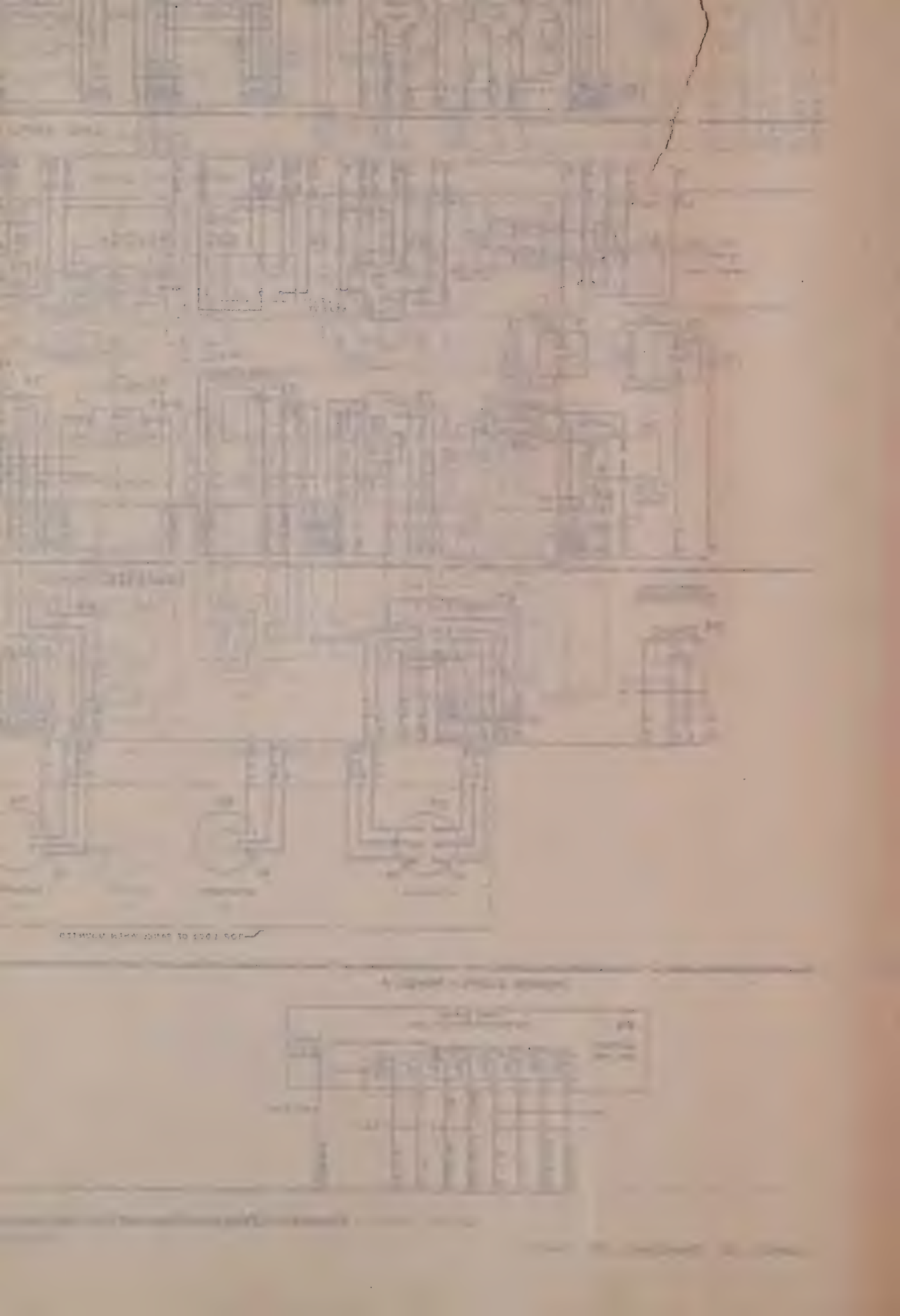


Figure 87. Telephone Terminal CF-1-A (serial numbers 617 and higher), line coil, measuring, line amplifier, and equalizer panels, wiring diagram.







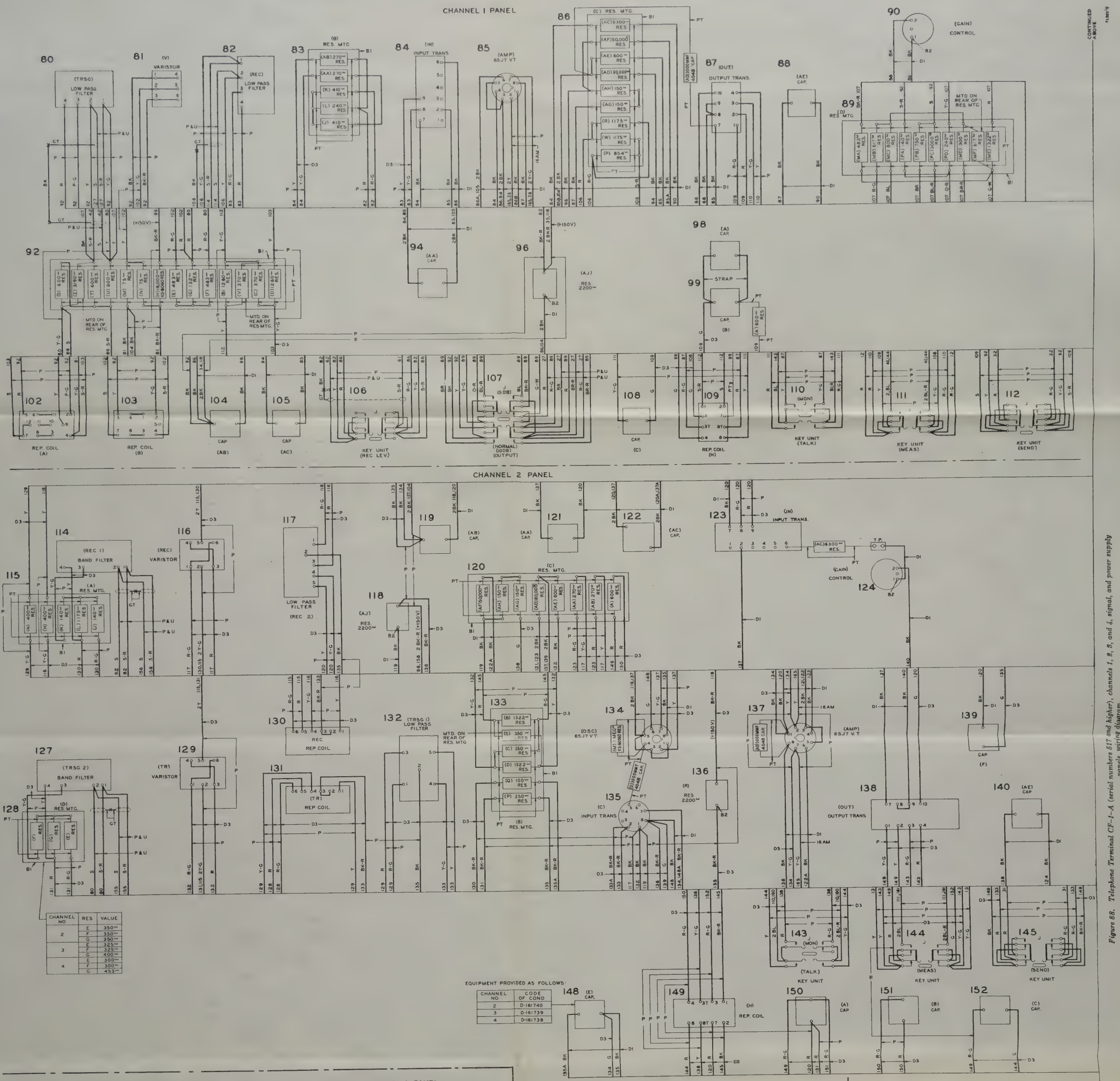
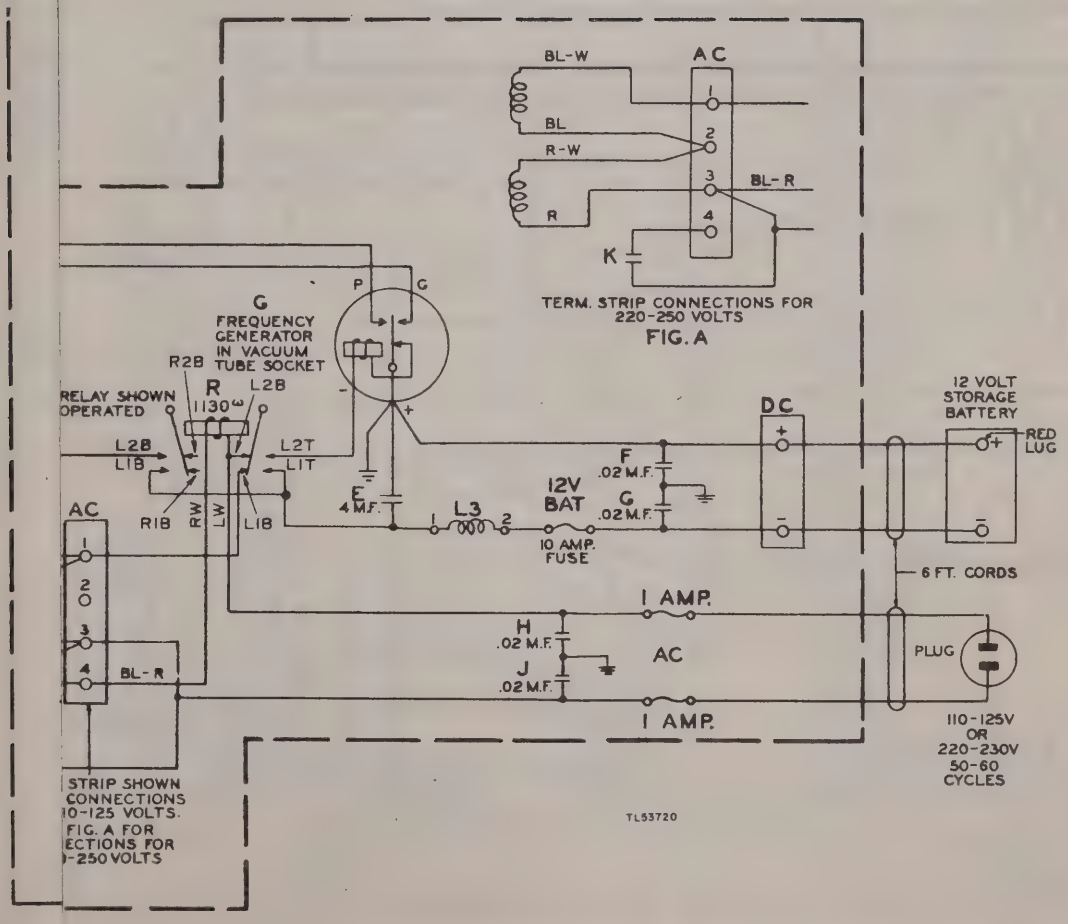
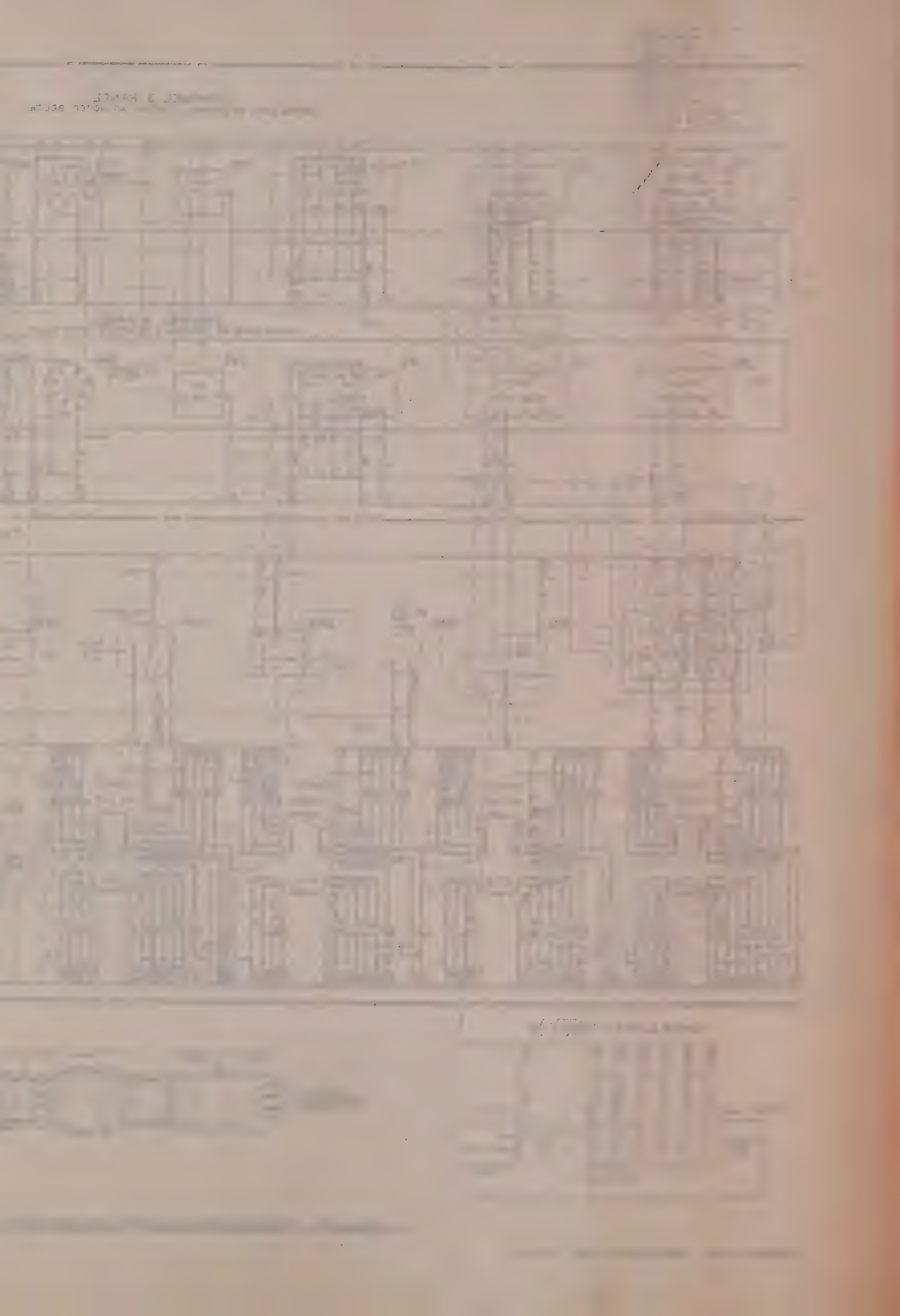


Figure 88. Telephone Terminal CF-1-A (serial numbers 517 and higher), channels 1, 2, 3, and 4, signal, and power supply panels, wiring diagram.


BL-W
AC
BL
R-W
BL-R
R
K
TERM. STRIP CONNECTIONS FOR 220-250 VOLTS
FIG. A
P
G
G
FREQUENCY GENERATOR IN VACUUM TUBE SOCKET
R2B
R
1130ω
L2B
RELAY SHOWN OPERATED
L2B
L1B
L2T
L1T
R1B
RW
LW
L1B
E
4 M.F.
L3
12V BAT
10 AMP. FUSE
F
.02 M.F.
G
.02 M.F.
DC
12 VOLT STORAGE BATTERY
RED LUG
6 FT. CORDS
AC
BL-R
1 AMP.
H
.02 M.F.
J
.02 M.F.
AC
1 AMP.
PLUG
110-125V OR 220-230V 50-60 CYCLES
STRIP SHOWN CONNECTIONS 10-125 VOLTS.
FIG. A FOR ECTIONS FOR -250 VOLTS
TL53720



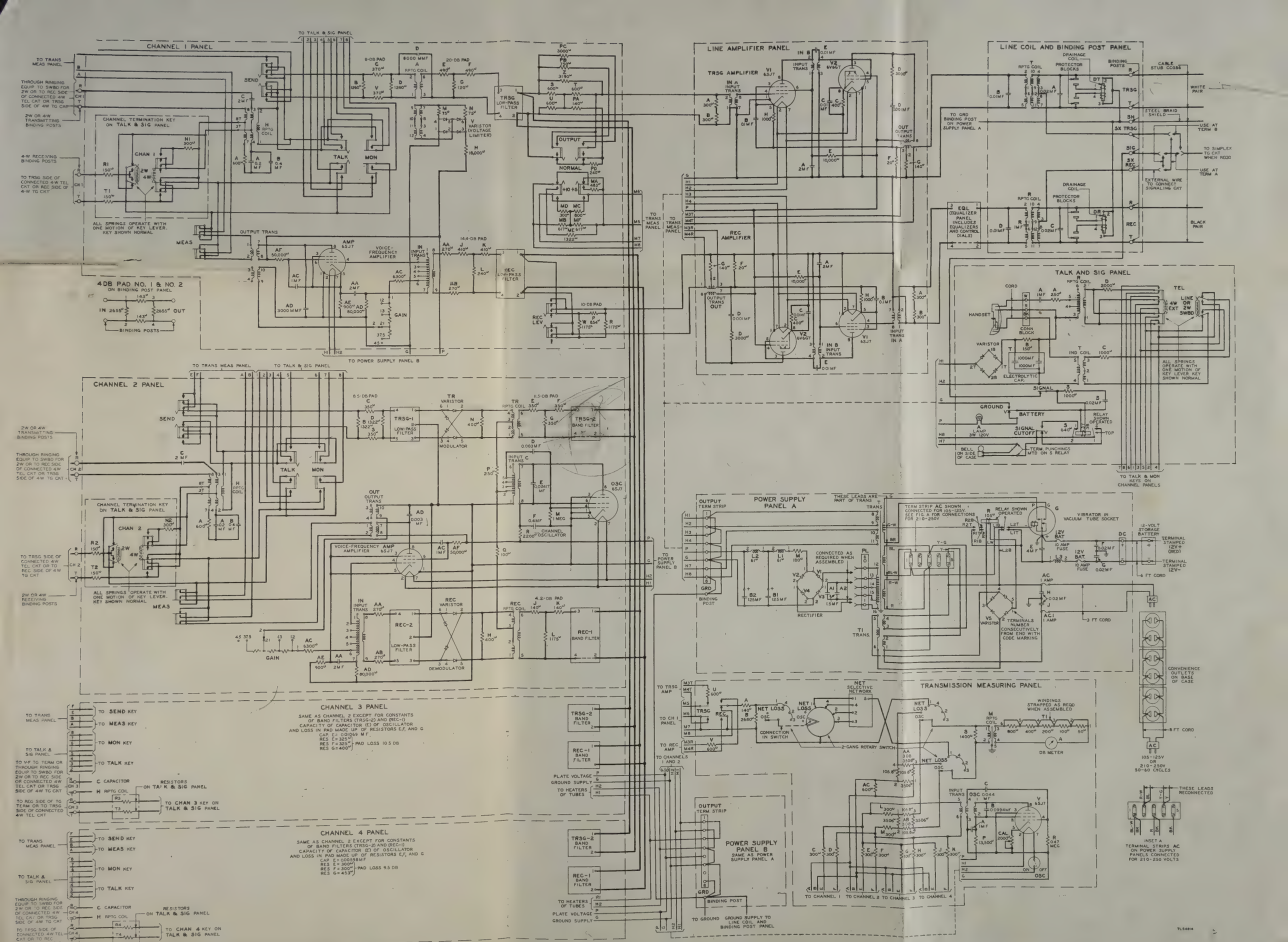
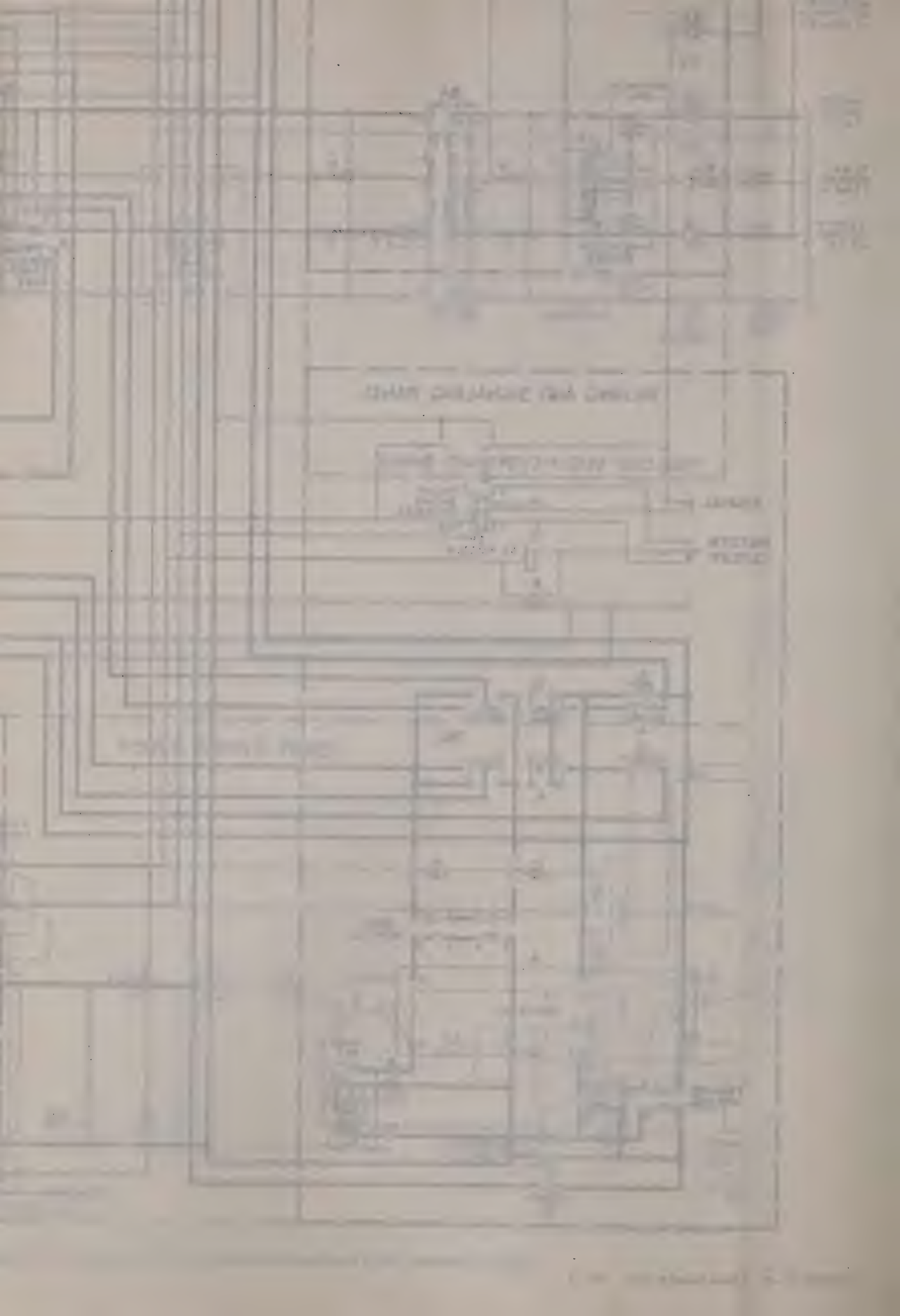
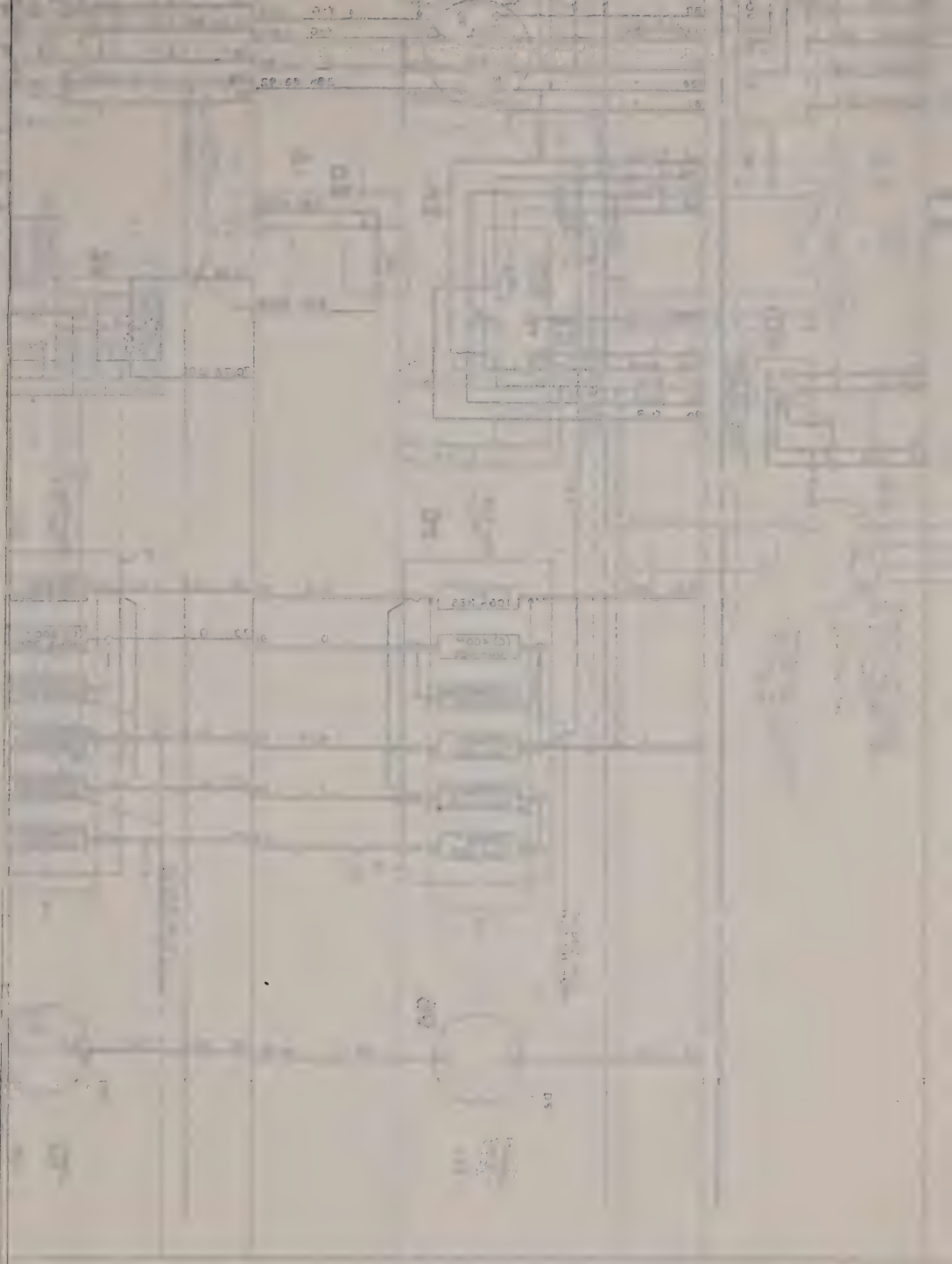
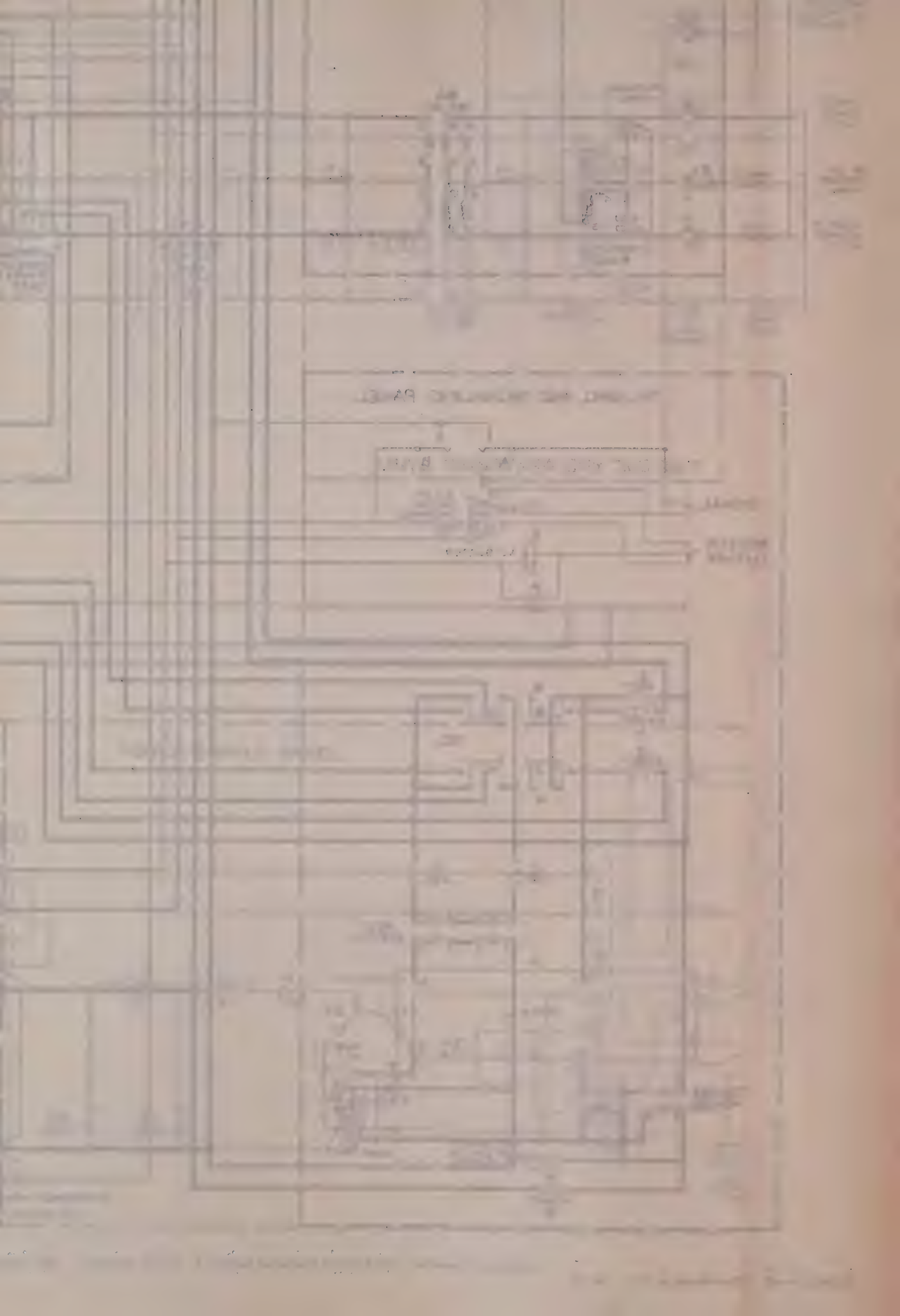


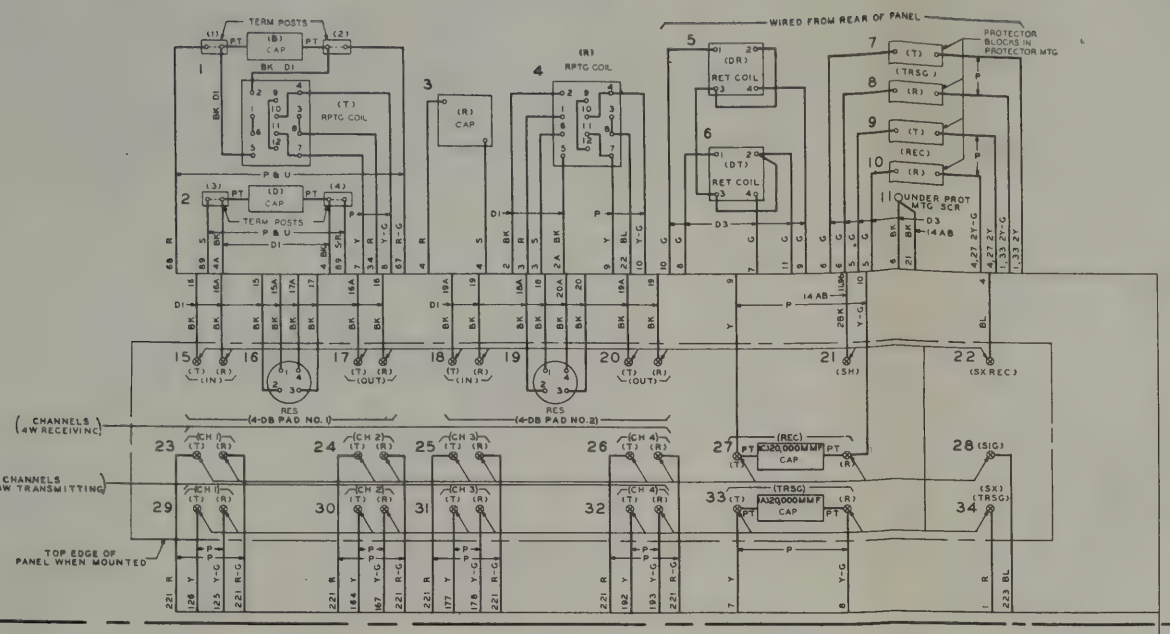
Figure 89. Telephone Terminal CF–1–B, schematic diagram.







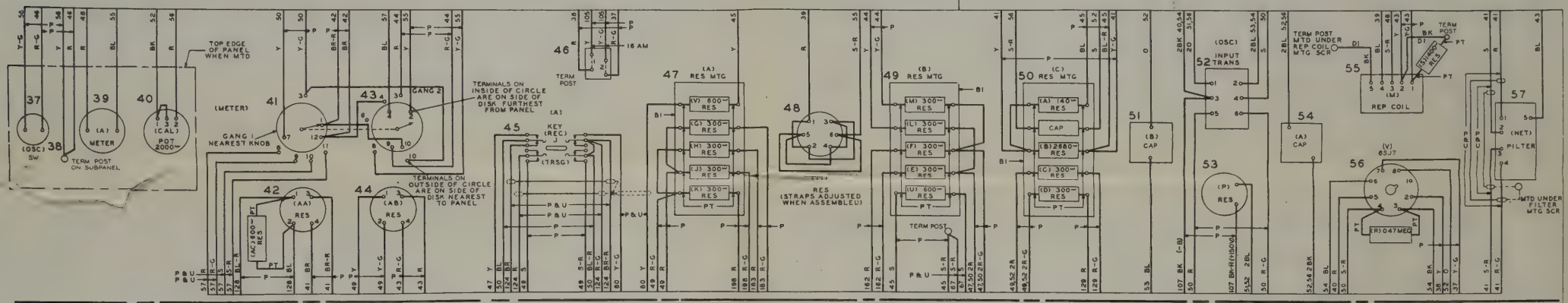
LINE COIL PANEL



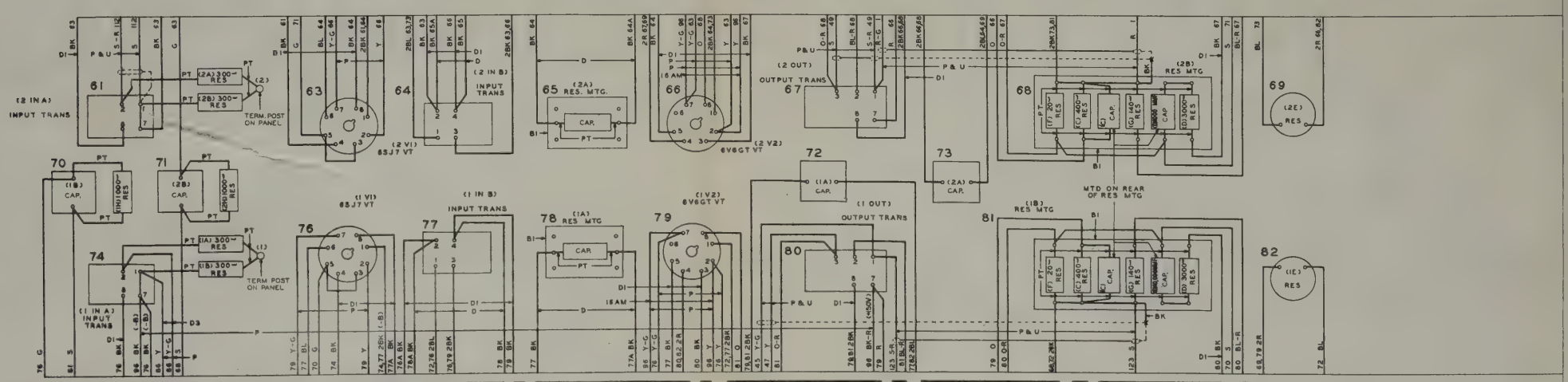
NOTES

1. WIRES NOT OTHERWISE SPECIFIED ARE 22AM
2. D WIRES RUN PERPENDICULAR AND PARALLEL TO EDGES OF MOUNTING PLATE IN THE SHORTEST POSSIBLE MANNER
3. D1 WIRES RUN DIRECTLY FROM TERMINAL TO TERMINAL IN THE SHORTEST POSSIBLE MANNER
4. D3 WIRING IS RUN LOOSE AND DRESSED BACK AGAINST THE MOUNTING PLATE
5. PT DENOTES LEADS FURNISHED AS PART OF APPARATUS.
6. LEADS DESIGNATED U ARE 22GA SHIELDED WIRE.
7. ALL STRAPS ARE BLACK 22AM EXCEPT WHERE BARE STRAPS ARE PERMISSIBLE
8. BL EDGE OF RESISTANCE MOUNTING NEAREST TO PANEL
9. B2, TERMINAL NEAREST PANEL
10. P DENOTES PAIR
11. J TOP END OF KEY LOOKING AT THE TERMINAL SIDE
12. - - - - DENOTES SHIELD CONNECTION
13. —×— DENOTES SPLICE
14. F. BROUGHT FROM CABLE FORM AT SEPARATE STITCH.

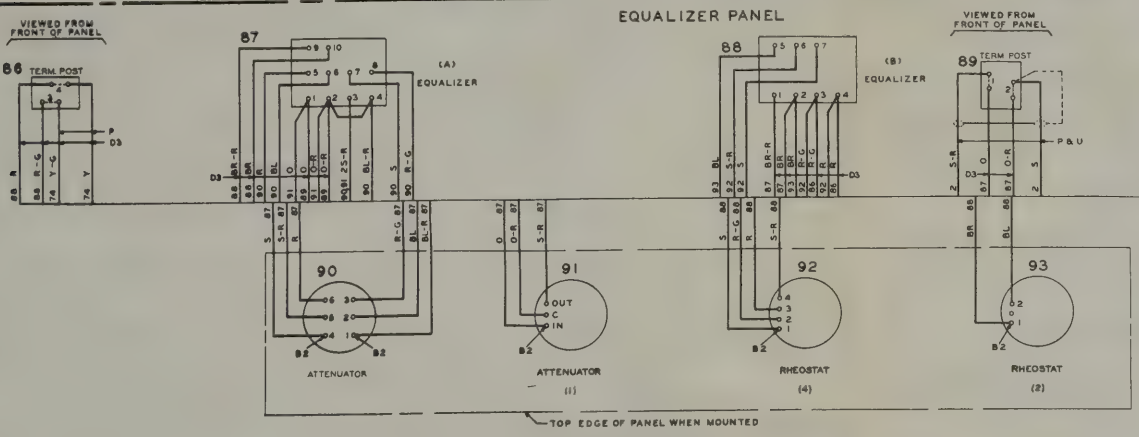
MEASURING PANEL



LINE AMPLIFIER PANEL



EQUALIZER PANEL



POWER SUPPLY PANEL A

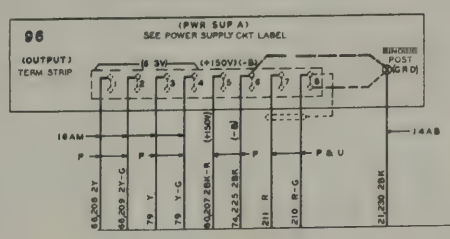


Figure 90. Telephone Terminal CF–1–B, line coil, measuring, line amplifier, equalizer, and power supply A panels, wiring diagram.

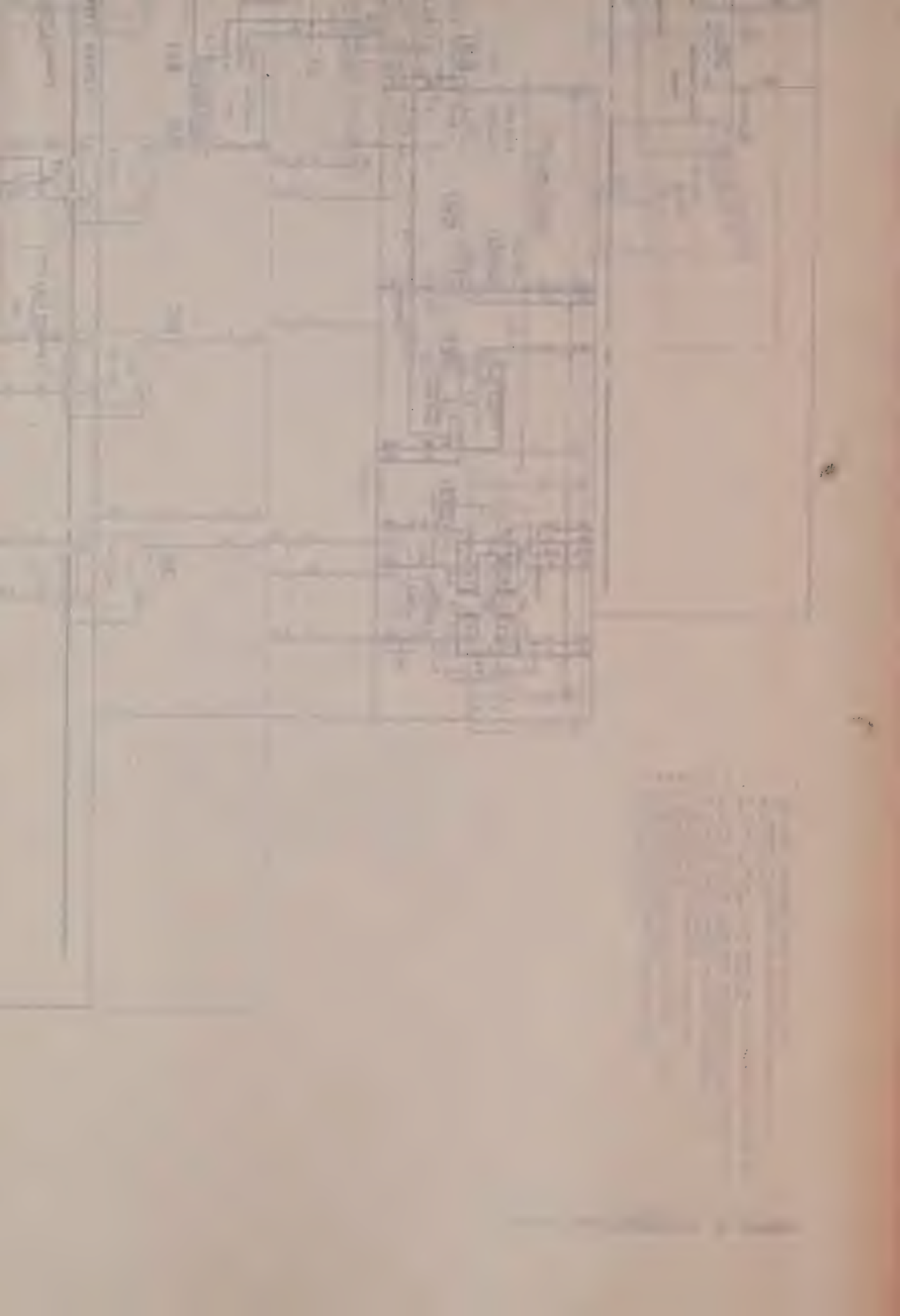
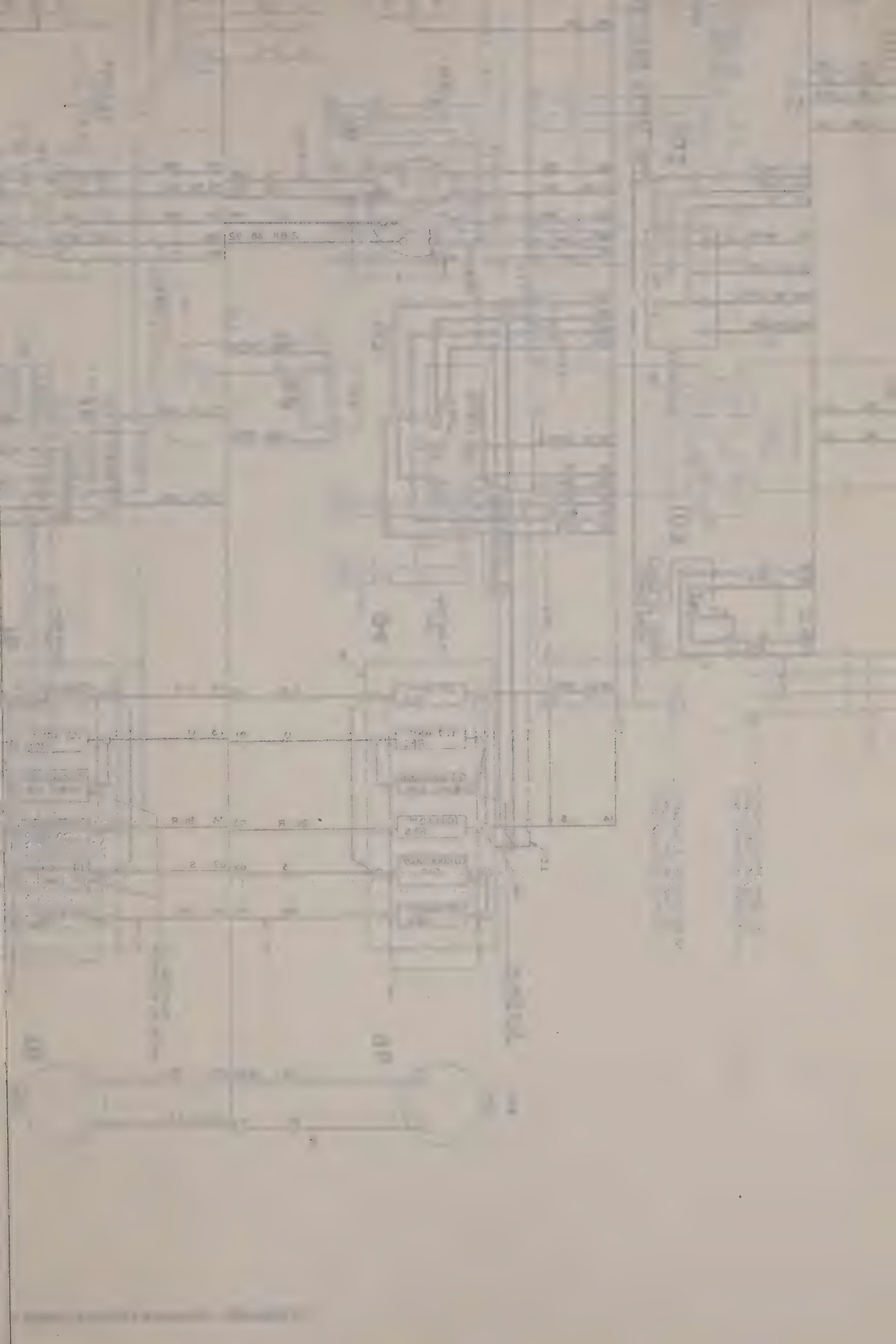
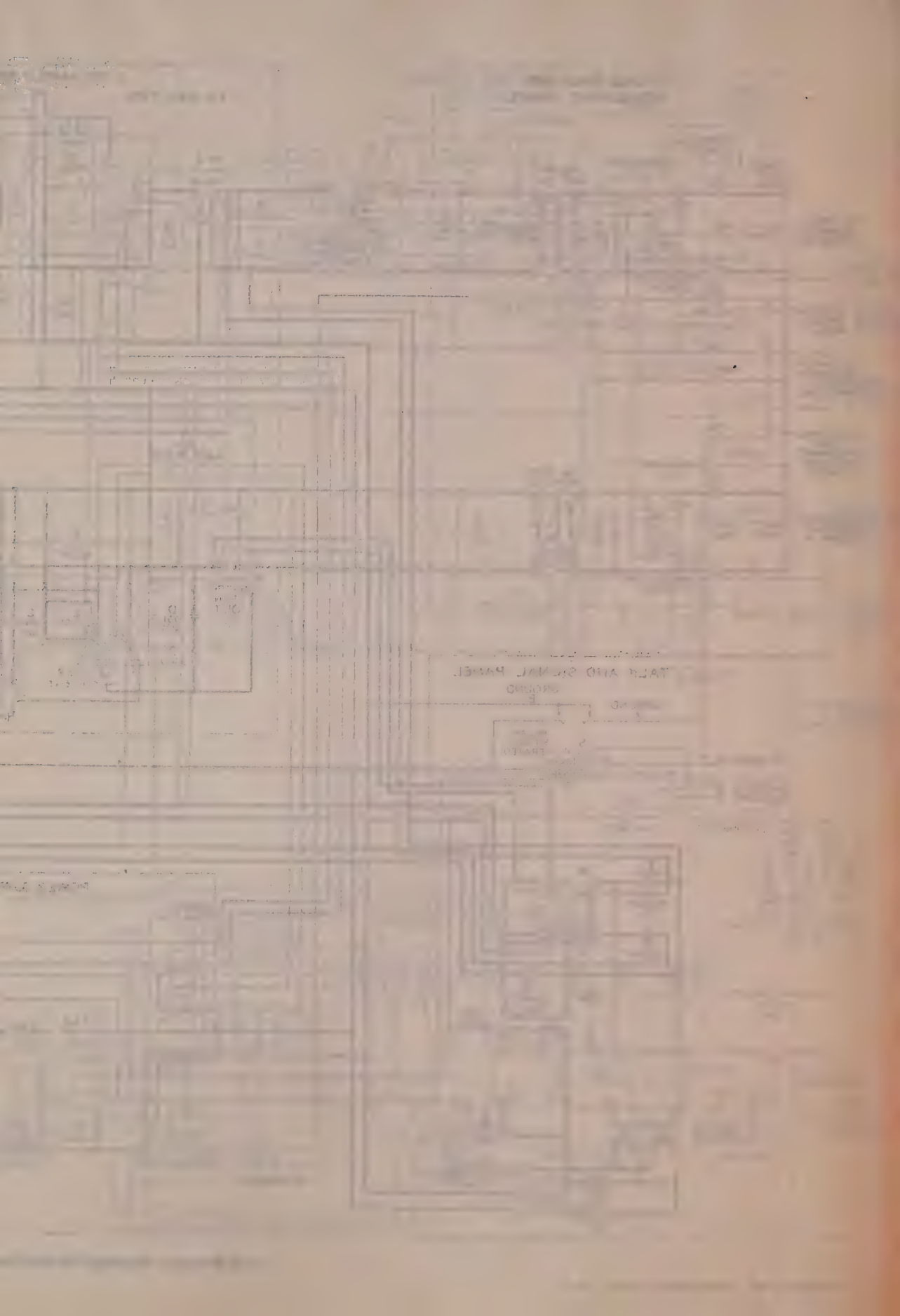


Figure 91. Telephone Terminal CF–1–B, channels 1, 2, 3, and 4, talk and signal, and power supply B panels, wiring diagram.





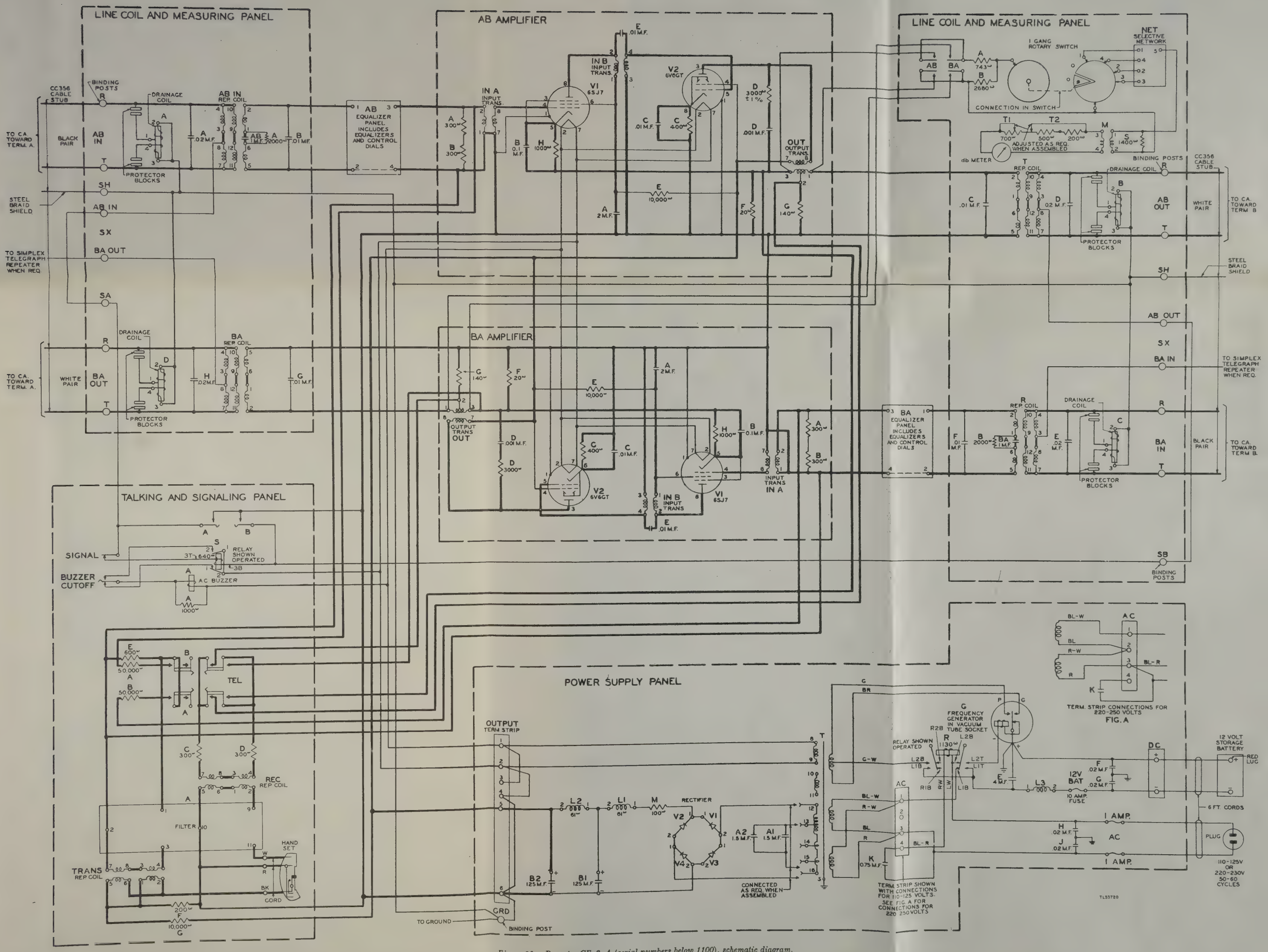
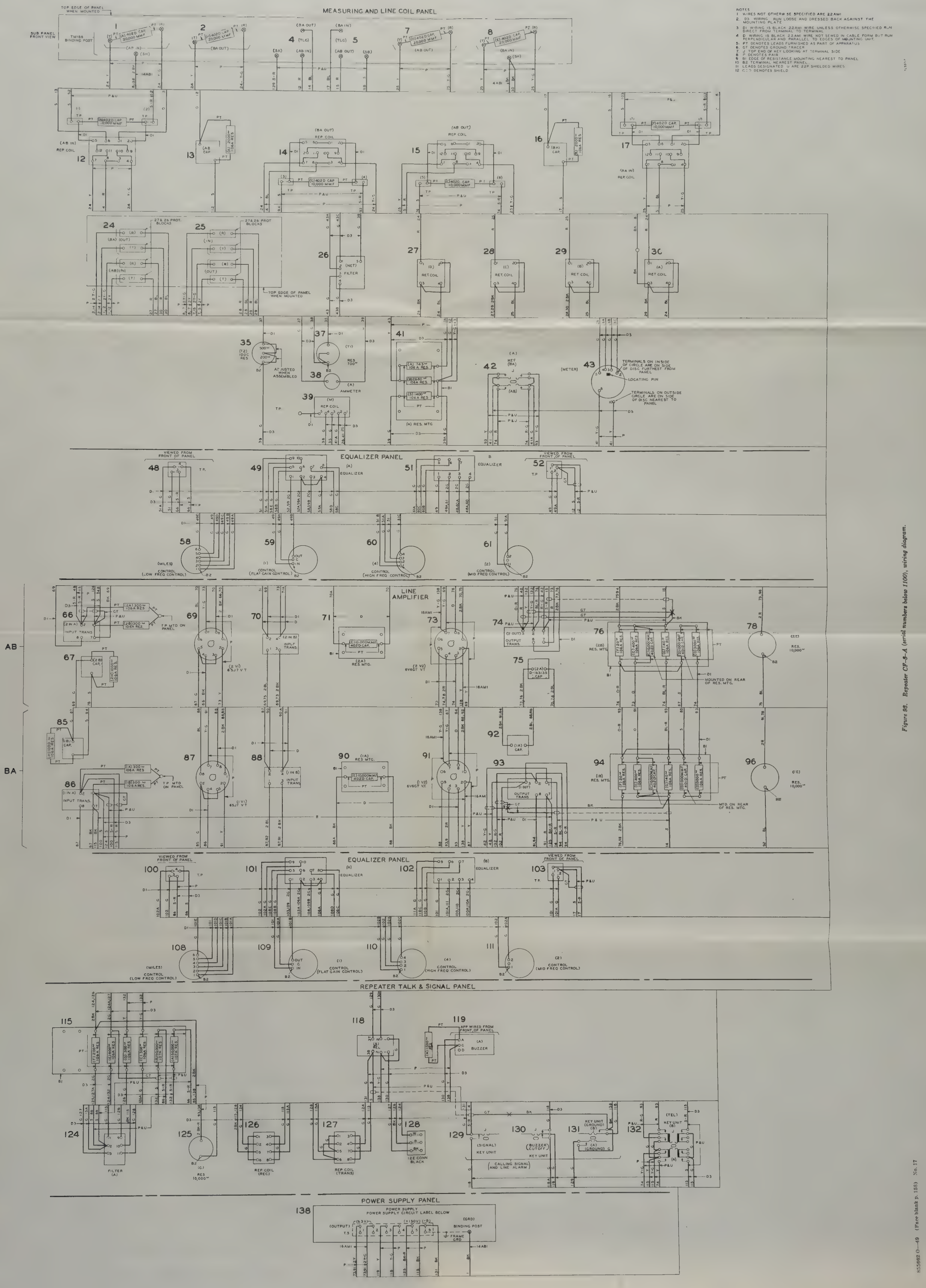


Figure 92. Repeater CF-3-A (serial numbers below 1100), schematic diagram.



NOTES
1 WIRES NOT OTHERWISE SPECIFIED ARE 22AMI
2. D3 WIRING RUN LOOSE AND DRESSED BACK AGAINST THE MOUNTING PLATE
3 D1 WIRING IS BLACK 22AMI WIRE UNLESS OTHERWISE SPECIFIED RUN DIRECT FROM TERMINAL TO TERMINAL
4 D WIRING IS BLACK 22AMI WIRE NOT SEWED IN CABLE FORM BUT RUN PERPENDICULAR AND PARALLEL TO EDGES OF MOUNTING UNIT.
5. PT DENOTES LEADS FURNISHED AS PART OF APPARATUS
6. GT DENOTES GROUND TRACER
7. J TOP END OF KEY LOOKING AT TERMINAL SIDE
8 P DENOTES PAIR
9 B1 EDGE OF RESISTANCE MOUNTING NEAREST TO PANEL
10 B2 TERMINAL NEAREST PANEL.
11 LEADS DESIGNATED U ARE 22P SHIELDED WIRES
12 [illegible] DENOTES SHIELD

Figure 98. Repeater CF-3-A (serial numbers below 1100), wiring diagram.

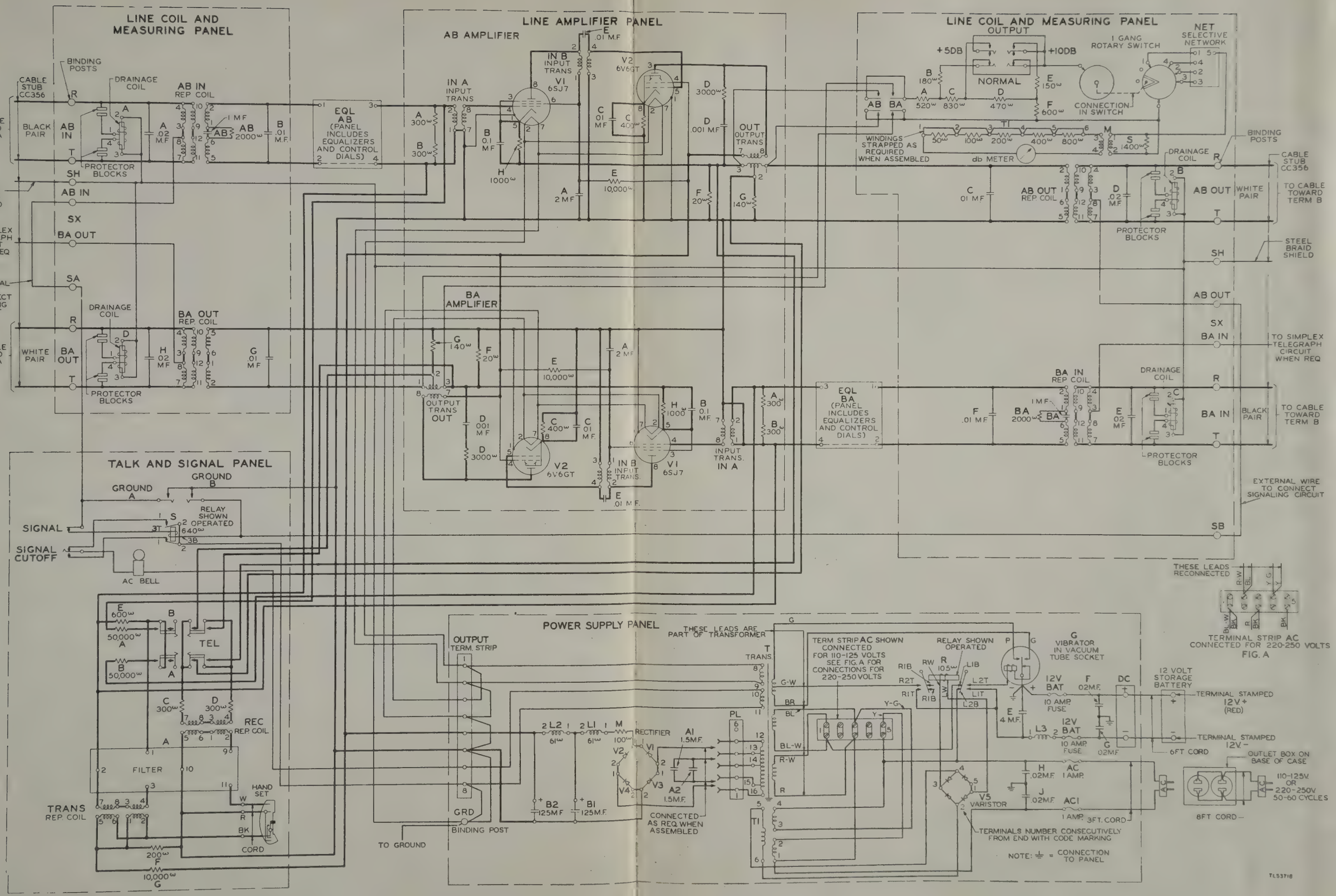


Figure 94. Repeater CF-3-A (serial numbers 1100 and higher), schematic diagram.

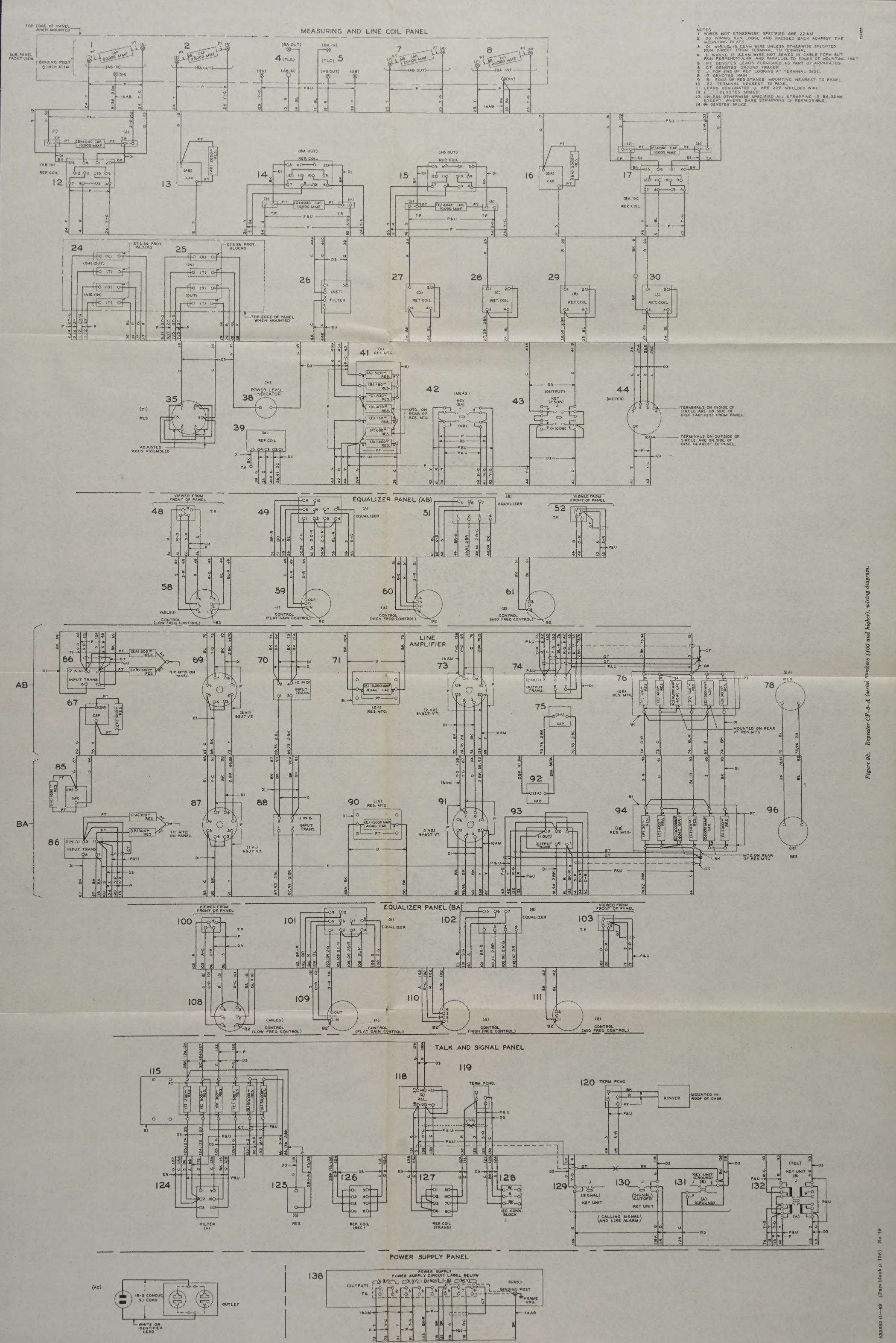


Figure 86. Repeater CF–3–A (serial numbers 1100 and higher), wiring diagram.

TALK AND SIGNAL PANEL
POWER SUPPLY PANEL
KEY CORD (CHART)
KEY TURN (CHART)
KEY TURN (RIGHT)
KEY TURN (LEFT)
KEY TURN (CENTER)
KEY TURN (CHART)
KEY TURN (CHART)
KEY TURN (CHART